CITY OF WINTERS

WATER SYSTEM MASTER PLAN

Prepared by:

CH2M Hill

Adopted
May 19, 1992

WATER SYSTEM MASTER PLAN

Prepared for

CITY OF WINTERS, CALIFORNIA

REGISTERED PROFESSIONAL ENGINEER
LACHI D. MORSE
Exp. 3/31/92
No. C 042639
CIVIL
STATE OF CALIFORNIA

REGISTERED PROFESSIONAL ENGINEER
DAVID A. PETERSON
No. C 043432
Exp. 6/30/92
CIVIL
STATE OF CALIFORNIA

This Document Has Been Prepared Under the Direction of a
Registered Professional Engineer

Prepared by

CH2M HILL
3840 Rosin Court, Suite 110
Sacramento, California 95834

May 8, 1992

SAC/T181/010.51

93 00710

SAC28849.A1

Section 1
WATER FACILITY MASTER PLAN

Prepared for

CITY OF WINTERS

This document has been prepared under the direction of a Registered Professional Engineer

Prepared by

CH2M HILL
3840 Rosin Court, Suite 110
Sacramento, California 95834

May 8, 1992

SAC/T181/010.51

Section 1
WATER FACILITY MASTER PLAN CONTENTS

CONTENTS (Continued)

Page

APPENDIXES

TABLES

FIGURES

INTRODUCTION

The City of Winters General Plan, adopted in May 1992, anticipates a 170 percent increase in population in the 20-year period between 1990 and 2010. Winters' population in 1990 was 4,693 and is expected to reach about 12,500 by the year 2010. Most of this growth is expected to the north of the City between Dry Creek and Interstate 505.

System piping for the water master plan will be altered slightly with changes in road layout, actual industry developed, and any significant land use alterations. Therefore, pipe sizing and costs as presented here are subject to further change during final design.

The Water System Master Plan includes the following:

- Estimate of future water demands
- Review of available long-term water supplies
- Evaluation of existing system
- Evaluation of the future system
- Budget-level cost estimates

STUDY AREA

The City of Winters is located in Yolo County about 30 miles west of Sacramento, California. Winters is on the western edge of the Sacramento River Valley against the eastern edge of the Coast Range Mountains.

The study area encompasses the area located within the City of Winters Urban Limit Line between Putah and Dry Creeks to the south and west, Interstate 505 to the east, and as far north as the City's existing wastewater treatment facility.

REPORT ORGANIZATION

The conclusions and recommendations of this study are summarized in the following section. Complete descriptions of the work performed appear in subsequent sections. Appendices A and B contain existing water system and future water system schematic plan sheets.

RECOMMENDATIONS

The recommendations for the City of Winters existing and future system are as follows:

1. A regular replacement program as outlined in this report should be implemented. The first sections of pipe to be replaced should be as follows:

    - The 4- to 8-inch-diameter pipe along Edwards Street between Main and East Streets with 12-inch-diameter pipe

    - The 2- and 4-inch-diameter pipe along Fourth Street between Grant Avenue and Russell Street with 12-inch-diameter pipe

    - The 6-inch-diameter pipe along Walnut Street between Grant Avenue and Dutton Street with 12-inch-diameter pipe

    - The 4-inch-diameter pipe along Russell Street between Emery Street and the dead end to the west with 8-inch-diameter pipe

2. Backup generators should be installed at all wells.

3. The City should examine each valve and fire hydrant in the downtown area (south of Grant Avenue) to determine if they are fully open and operational. A systematic check of the system should be made by opening and closing various in-line valves and fire hydrants to identify localized mainline, valve, or fire hydrant problems. Once problems are identified, they should be corrected.

4. City standards should be adopted for types of pipe, valves, corporation stops, service connections, etc. that will be used in the system. We recommend the use of a minimum Class 150 polyvinyl chloride (PVC) or ductile iron for all future pipe. Corporation stops and other metallic fittings should be bronze, which is more corrosion-resistant than other metallic fittings. Galvanized steel should not be used in conjunction with copper tubing or other incompatible metals as its working life will be reduced by corrosion. Valves should be from a single manufacturer for easy stock piling of replacement parts.

5. The City should pursue a potential surface water supply to decrease the City's dependency on groundwater.

6. Replace Well 1.

7. Install variable frequency drives on Wells 2 and 3 and on Well 1 at time of replacement.

8. Discontinue the use of the three in-line check valves.

9. The two existing elevated tanks should be removed from service after installation of variable frequency drives and backup generators at existing wells. The tanks are over 80 years old and are set at too low an elevation to be effective in the future.

10. The previously planned Well 6 and two additional wells should be drilled in order to serve the future system. They should be equipped with variable frequency drives.

11. Future service connections should be plumbed for installation of water meters. Water meters will be required on all future connections.

12. Provide a new telemetry system to monitor, control, and provide recordkeeping for the existing and future wells.

13. Install two additional fire hydrants in the existing system, one about the middle of Mermod Road and the other in the alley behind the fire department.

14. Install future water mains in accordance with those shown in Appendix B. Actual improvements may vary from those shown, but overall hydraulic capacity and design criteria must be maintained.

15. The moderate conservation program should be adopted as detailed in the Urban Water Management Plan (Section 3 of this report).

WATER DEMANDS

EXISTING DEMANDS

The City has maintained records for the amount of water pumped from Wells 1, 2, 3, and 4 since May 1989. Records for Well 5 have been kept since the well went into production in September 1989. The well records are shown in Table 1. The current population of 4,693 is served under 1,401 accounts by the City. Of these, 22 are metered and the remaining 1,379 are flat rate accounts. Statistical records for these accounts have been kept since May 1989.

Table 1
City of Winters Existing Well Records
(Gallons)

	Well 1	Well 2	Well 3	Well 4	Well 5	Total
May 1989	3,518,000	23,000,000	21,000,000	7,982,000		55,500,000
June 1989	5,802,000	22,088,000	20,072,000	10,777,000		58,739,000
July 1989	9,174,000	28,886,000	20,727,000	13,336,000		72,123,000
Aug 1989	18,575,000	16,565,000	18,159,000	12,206,000		65,505,000
Sept 1989	7,321,000	9,612,000	10,923,000	7,301,000	7,101,000	42,258,000
Oct 1989	5,554,000	10,841,000	3,332,000	5,692,000	7,353,000	32,772,000
Nov 1989	4,271,000	5,976,000	5,366,000	4,639,000	6,949,000	27,201,000
Dec 1989	3,164,000	4,393,000	3,978,000	3,231,000	4,400,000	19,166,000
Jan 1990	3,666,000	5,450,000	4,258,000	3,576,000	4,815,000	21,865,000
Feb 1990	3,012,000	4,494,000	4,464,000	3,395,000	3,990,000	19,355,000
Mar 1990	4,134,000	5,800,000	5,713,000	4,978,000	6,470,000	27,095,000
Apr 1990	5,523,000	8,233,000	11,333,000	7,242,000	13,106,000	45,437,000
Total	73,714,000	145,338,000	129,325,000	84,455,000	54,184,000	487,016,000
gpm	142	280	249	162	104	937

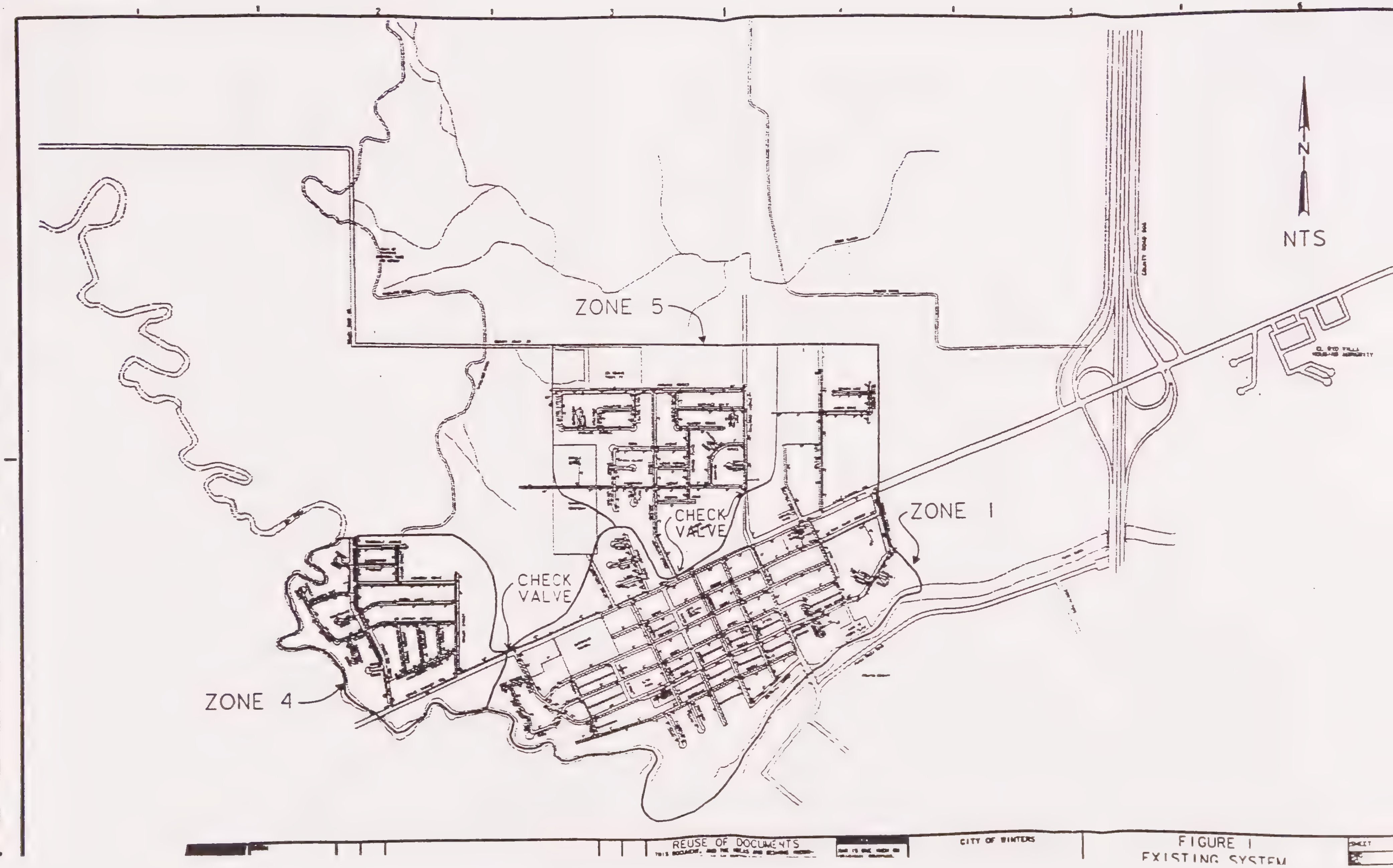
Note: Gallons per minute (gpm) were calculated on the basis of 361 days, which corresponds to the number of recorded days.

Because there are no records for the City prior to May 1989, long-term demands were determined for the system using existing records from the Cities of Folsom and Davis. The average water demands for these cities by land use category are shown in Table 2.

Table 2 Water Demand		
Land Use	Water Demand (ac-ft/ac-yr)	Water Demand (gal/ac-yr)
Rural Residential (0.5 - 1 dwelling unit/ac)	3.4	1,108,000
Low Density Residential (1.1 - 4 dwelling units/ac)	3.4	1,108,000
Medium Density Residential (4.1 - 6 dwelling units/ac)	3.4	1,108,000
Medium High Density Residential (6.1 - 10 dwelling units/ac)	3.8	1,238,000
High Density Residential (10.1 - 20 dwelling units/ac)	3.8	1,238,000
Neighborhood Commercial	3.8	1,238,000
Highway Service Commercial	3.8	1,238,000
Central Business District	3.8	1,238,000
Planned Commercial	2.0	652,000
Office	2.0	652,000
Light Industrial	2.0	652,000
Heavy Industrial	4.5	1,467,000
Business/Industrial Park	2.0	652,000
Planned Commercial/Business Park	3.8	1,238,000
Public/Quasi-Public	2.0	652,000
Recreation and Parks	3.0	978,000
Open Space (irrigated)	3.0	978,000

Using the generalized per-acre demands from these two cities allowed averaging between several wet and dry years to estimate a current average annual demand of 1,010 gallons per minute (gpm). This compares with City of Winters records that show an average 937 gpm used from May 1989 to May 1990. The higher estimated demand reflects averaging several wet and dry years.

The existing water system currently operates as three separate pressure zones (Figure 1) connected by check valves. Zone 1 includes Wells 1, 2, and 3 and Tanks 1 and 2 (located at Wells 1 and 3, respectively). Well 1 is currently out of operation. Zone 1 also serves three businesses in Solano County outside the city limits. These businesses are served by a 1-inch-diameter pipe, which crosses Putah Creek at Railroad Avenue. Zone 4 contains Well 4, and Zone 5 contains Well 5. Zones 4 and 5 operate at a higher pressure than Zone 1. The check valves are closed except in cases of extreme low pressures in Zones 4 or 5. This occurs if Well 4 or 5 is out of production or if fire flow is being used in either zone.


ZONE 5
ZONE 1
ZONE 4
CHECK VALVE
CHECK VALVE
N
NTS
REUSE OF DOCUMENTS
CITY OF WINTERS
FIGURE 1
EXISTING SYSTEM

Because the three zones operate separately, except in cases of emergency, demands were compared zone by zone to actual well records. Well 5 has not been in production for a full year. Therefore, estimates were made as to how much of the flow from Wells 1, 2, and 3 was going to customers now served by Well 5. Well records were correspondingly adjusted and compared to the model on a zone-by-zone basis as shown in Table 3. The comparison shows that the May 1989 through May 1990 demands were about 7 percent less than the demands in an average year. This is an expected result because 1989 was a dry year and conservation consciousness was high.

Table 3
Average Annual Water Demand By Zone

	Zone 1 (gpm)	Zone 4 (gpm)	Zone 5 (gpm)	Total (gpm)
1989-90 Well Records	671	162	104	937
Adjusted Flows[a]	541	162	234	937
Adopted Average[b] Annual Demand	550	200	260	1,010

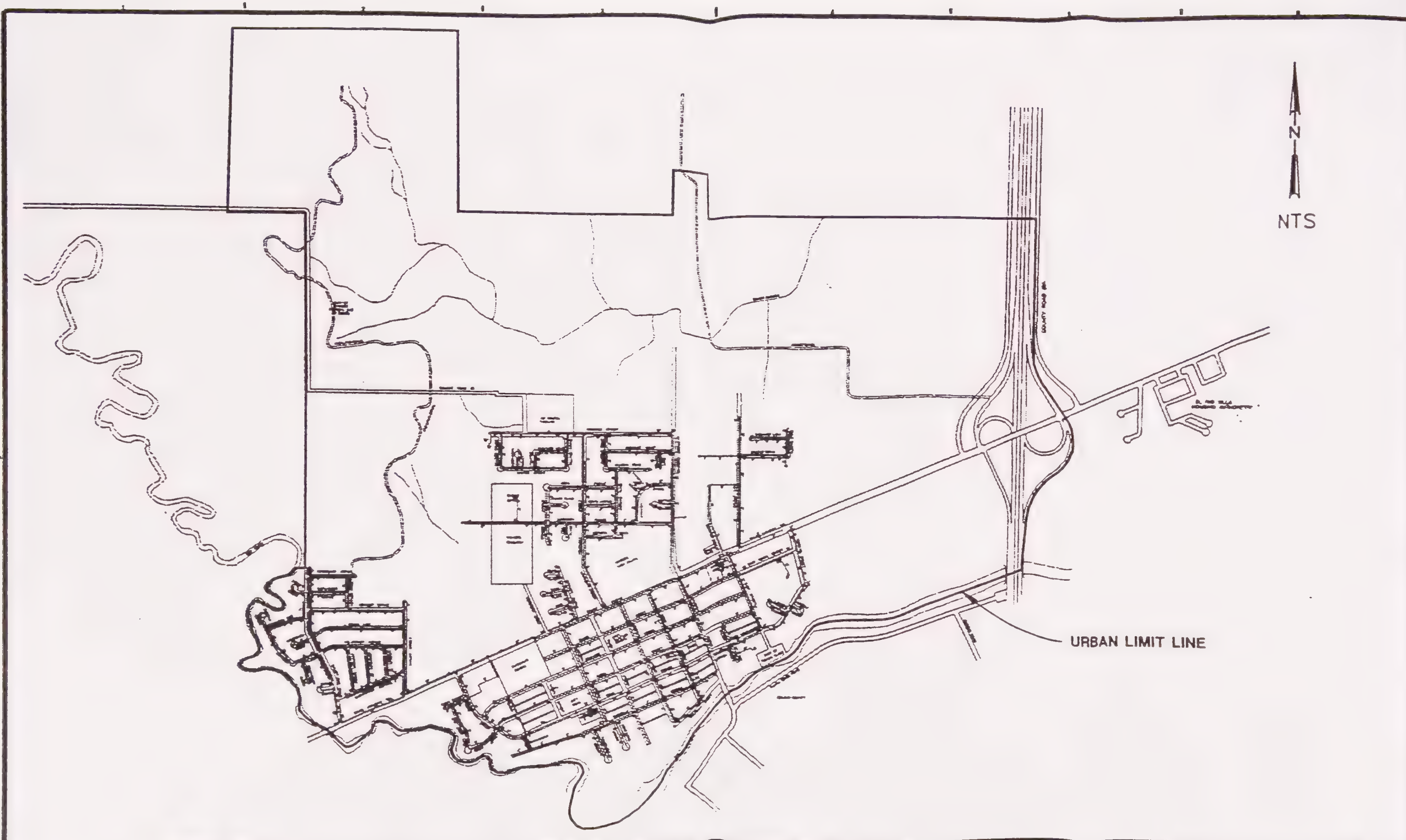
[a]Well records were adjusted to synthesize flows from Well 5 from May 1989 through September 1989. The corresponding flows were then deducted from Zone 1 Wells.
[b]Based on Table 2 demand schedule.

FUTURE DEMANDS

Future demands are based on buildout by the year 2010 in the area defined within the Urban Limit Line (Figure 2) in the City of Winters General Plan, adopted in May 1992. This area is bounded approximately by County Road 32a to the north, by County Road 88 and Dry Creek to the west, Putah Creek to the south, and by Interstate 505 to the east. The population in 2010 is estimated to be 12,500. The current population, as of the 1990 census, is 4,693.

ANNUAL USE

Average annual water demand estimates are based on future land use densities and intensities specified by the City of Winters General Plan (May 1992). This potentially includes the development of new areas and the infill of areas in the existing portions of the City. In the year 2010, the average annual water demand is estimated to be approximately 3,210 gpm or 5,180 acre-feet. The demand will vary depending on the type of industry actually built and the actual development patterns.



CITY OF WINTERS

WINTERS CALIFORNIA

FIGURE 2
EXISTING SYSTEM
URBAN LIMIT LINE

A water conservation plan was developed concurrently with the water master plan. Refer to the Urban Water Management Plan in Section 3 for greater detail. The report recommends the City adopt a water conservation ordinance that is estimated to reduce future demand for water by 16 percent.

The water master plan used the current rate of water usage to determine future water supply needs. However, if conservation efforts reduced the demand as previously stated, then one additional well would not be needed in the year 2010. System piping requirements would remain about the same as a result of pipe sizes being determined primarily from fire flow requirements.

MAXIMUM DAY DEMAND

Maximum day demand is the highest demand most likely to occur for a day during a year. Maximum daily water production values were obtained from the Cities of Davis and Folsom because the City of Winters does not keep these records. Based on values from those cities, the ratio of the maximum day demand to the average day demand used is 2.0. This ratio was used together with the fireflow requirements to estimate required mainline pipe sizes.

PEAK-HOUR DEMAND

Another demand condition for the water system analysis is the highest hourly (peak-hour) demand that is likely to occur during a year. A typical demand curve for municipal water systems gives a peak-hour demand of 1.75 times the maximum day demand. The resulting ratio of peak hour to average day demand is 3.5. This value is also used by the City of Davis for planning of future systems. The peak-hour demand is used to determine well capacities.

FIRE FIGHTING REQUIREMENTS

Fireflow demands place municipal water systems under severe operating conditions. The ability of the system to deliver the required flow at sufficient pressure is important for the community's safety.

The Insurance Services Office grades municipal protection ability and establishes local insurance premium rates. City of Winters Fire Department prescribed fireflows are 1,500 gpm for residential, 2,000 gpm for commercial, and 3,000 gpm for industrial areas. The minimum required pressure under fireflow conditions is 20 psi.

SUMMARY

Existing Demands:

- Average Annual Demand - 1,010 gpm
- Maximum Day Demand - 2,020 gpm
- Maximum Day Demand Plus 1,500-gpm Fireflow - 3,520 gpm
- Maximum Day Demand Plus 3,000-gpm Fireflow - 5,020 gpm
- Peak-Hour Demand - 3,535 gpm

Future Demands (including existing system) for General Plan in the year 2010:

- Average Annual Demand - 3,210 gpm
- Maximum Day Demand - 6,420 gpm
- Maximum Day Demand Plus 1,500-gpm Fireflow - 7,920 gpm
- Maximum Day Demand Plus 3,000-gpm Fireflow - 9,420 gpm
- Peak-Hour Demand - 11,235 gpm

WATER SUPPLY

GROUNDWATER

The City of Winters currently obtains all its water supply from wells and has Putah Creek underflow water rights of 1.5 cubic feet per second (cfs). This is equivalent to 673 gpm. Underflow rights refer to the water that flows beneath Putah Creek in aquifer gravels. The City of Winters' right does not allow use of water flowing above ground in the creek.

Future use of additional groundwater not taken from the underflow of Putah Creek is currently unrestricted. Possible future restricting factors are the lowering of the groundwater table, water quality degradation, and the current adjudication of the waters of the Putah Creek basin.

Groundwater levels monitored by the Department of Water Resources show a fairly consistent water level for the past 30 years. The closest monitoring well is located about 1 mile west of Winters. The water level in this well has fluctuated between 50 and 67 feet below ground elevation.

A groundwater study was conducted in April 1991. Refer to the Groundwater Study in Section 2 for details. This study reported that there appears to be adequate groundwater to supply the City of Winters into the year 2010 up to a population of 12,500.

SURFACE WATER

Surface waters in the vicinity of Winters include Putah Creek, Dry Creek, Moody Slough, and Willow Canal. As previously discussed, the City has underflow rights from Putah Creek. The U.S. Bureau of Reclamation (USBR) holds rights to most of the Putah Creek water. Water stored by the USBR in Lake Berryessa is contracted to entities in Yolo, Solano, and Napa Counties. The Willow Canal and Chapman Reservoir, owned by Yolo County Flood Control and Water Conservation District, convey water from Cache Creek. Cache Creek is currently overappropriated. However, if surface water could be obtained from a City-sponsored surface water project in the foothills to the northwest, Willow Canal and Chapman Reservoir facilities might be available to convey water to the City of Winters. Obtaining surface water would reduce the City's dependence on groundwater as its sole source of supply.

EXISTING WATER SYSTEM

GENERAL

There are five well sites, four of which are currently operating within the City system. In 1989, the corresponding pumps were rated by Pacific Gas and Electric (PG&E) as operating with excellent efficiencies, ranging from 75 to 80 percent. The pumps vary in size from 60 hp to 100 hp, with well production at approximately 1,500 gpm each. PG&E conducts yearly pump and motor efficiency tests on all wells.

The three oldest wells are located in Zone 1. The two remaining wells were added to outlying areas in Zone 4 and 5 as development spread to the north and west of town. Well 1 has been recently taken out of service because of dropping groundwater levels causing oil to be pumped into the service lines. A layer of lubricating oil, used by the pump, floats on top of the water level in the well. Oil floating in the well is a normal occurrence; oil being pumped into the service lines is not. The well also has a badly corroded casing and a pump bowl lodged in the side of the casing.

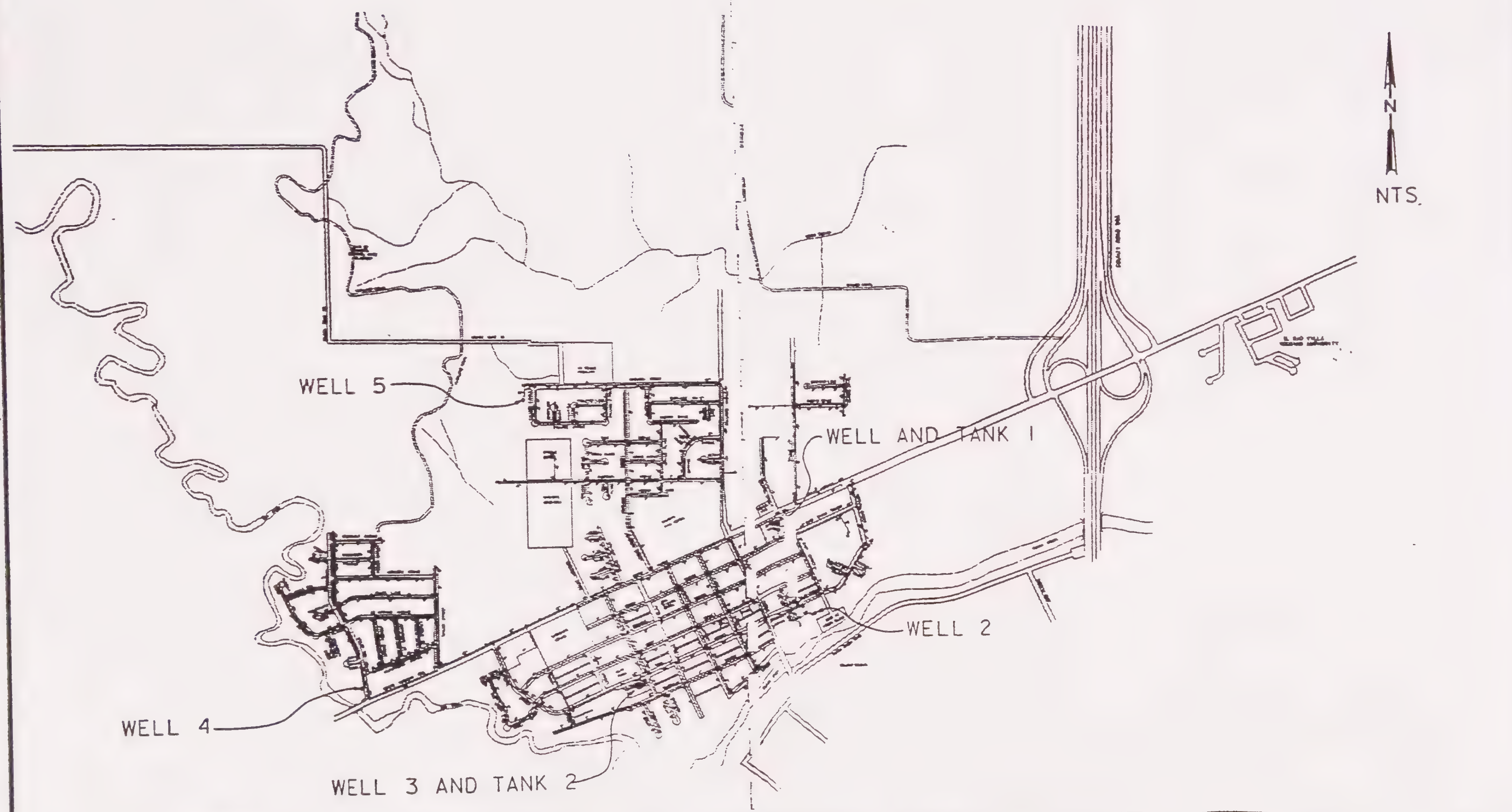
OPERATIONAL STORAGE AND EMERGENCY SUPPLY

The water distribution system includes two elevated storage tanks, Tanks 1 and 2. These tanks, thought to have been built around 1911, have capacities of 100,000 gallons each. The tops of both tanks are approximately 100 feet above ground elevation. Maximum operational pressures throughout the City are determined by Tank 1. Tank 2 has over-flowed quite often into the surrounding residential development. An automatic shutoff valve was first installed in about 1985, but the tank continued to overflow because of the high shutoff setting of the valve. In about 1987, shutoff pressure of the valve was reset to 32 psi, successfully taking care of the overflow problem. See Figure 3 for well and tank locations.

The ability of the system to deliver water during power outages is limited to the capacity of the elevated tanks. The 200,000-gallon storage capacity would last about 3 hours under average demand conditions. The pumps are driven by electric motors and there are currently no sources of backup power.

DISTRIBUTION SYSTEM

The distribution network is generally made up of 2- to 10-inch lines and one 12-inch main, which runs down Grant Avenue. Pipes range in age from 4 to 100 years old. The pipe between 25 and 100 years old is a combination of lined and unlined cast iron, and a section of 2-inch galvanized steel pipe. Pipe placed since that time is cement lined and coated ductile iron, asbestos cement, or PVC. Unlined cast iron pipe tends to corrode much faster then the other types of pipe that make up the system.



REUSE OF DOCUMENTS

CITY OF WINTERS

WINTERS CALIFORNIA

FIGURE 3
EXISTING SYSTEM
WELL AND TANK LOCATIONS

Development along Walnut Lane has left that area with only a single main serving the northern end of the street. This area is also located the farthest away from its supply wells, causing wide fluctuations in pressure to this area. Future development will complete loops to serve this area, and a new well is planned for this vicinity.

Fire hydrant tests have shown that hydrants do not provide the recommended 1,500 gpm in several areas in Zone 1. In addition, pressures below the required residual of 20 psi were found in almost all parts of the existing system. In the past the fire tanker truck has made up for these deficiencies. Improvements recommended in this Master Plan address these problems.

TELEMETRY SYSTEM

The telemetry system is used to control the operation of the two pumps (2 and 3) and two elevated tanks (1 and 2) in Zone 1. Zones 4 and 5 each have one variable frequency pump currently set at about 44 psi. The telemetry system is supplied by electrical power without a backup source. Backup power could be supplied by installation of a generator.

The telemetry system automatically switches pumps on and off in response to the water elevation in Tank 1. Tank 1 is set for shutoff when it reaches 95 percent full, which corresponds to approximately 40 psi at the ground elevation directly below the tank. This setting ensures that this tank does not overflow. When the water in Tank 1 reaches an elevation corresponding to 87 percent full, the first pump comes on. If the water level continues to drop, a second pump comes into service when the tank reaches 80 percent full. When a third pump is online, and with continued drawdown in the tank, the third pump will come on at the setting of 75 percent full. When all three pumps are running and the demand begins to decline, the tank begins to refill. When the tank is 75 percent full, the last pump to come online shuts off. If the demand continues to fall, the second pump shuts off when the tank is 80 percent full. The remaining pump will continue to serve the demands and fill the tank. When the tank is full, the remaining pump shuts off, the tank begins to drain, and the cycle begins again. The three pumps are automatically rotated by the telemetry system as to which pump comes on first, second, and third. Each pump has manual controls but does not have low-pressure override switches.

Check valves connecting Zones 4 or 5 to Zone 1 open allowing Zone 1 pumps and tanks to supplement the required flow when the pressure in Zone 4 or 5 is lower than the pressure in Zone 1.

RECORDING SYSTEM

The level in Tank 1 is automatically recorded on a continuous flow recorder. Storage in Tank 3 is not recorded. Well production has been manually recorded at monthly intervals since May 1989. Prior to that time, well production was not recorded.

SYSTEM ANALYSIS

A network computer model of the existing system was developed for use in preparing this master plan.

AVAILABLE DATA

Information used to construct and calibrate the model included pipe type, size, approximate age, and layout; tank and ground elevations; well pump curves; well production records; and pressures throughout the system.

Pipe sizes and locations were obtained from City water main system plan sheets; ground elevations were obtained from 1-foot interval contour maps supplied by the City. Pump curves and well production records were also provided by the City.

Written records of pipe type and age, tank elevations, or pressures throughout the system are not available. Therefore, pipe age and type and tank elevations were estimated by City staff. The City Fire Department, City Public Works Department, and CH2M HILL conducted fireflow tests to estimate pressures.

CALIBRATION OF MODEL

Fireflow tests were conducted at locations in the system in May 1990 to estimate system operating characteristics. For each test, a single fire hydrant was opened and allowed to flow 1 to 5 minutes until the system stabilized. Flows and pressures were recorded at all wells, tanks, and the flowing hydrant both before the test (static conditions) and during the test (dynamic conditions). Results of the tests are given in Table 4.

Computer analyses of the system for each test closely matched the test data. Exceptions include Test No. 4, in which the extremely low fireflows are probably the result of localized obstructions such as a closed or partially closed valve, loss of pipe cross-sectional area to corrosion, or debris accumulation. These conclusions are based on the fact that hydrants in neighboring streets were receiving at least twice the amount of flow and 10 times the pressure during the fireflow test. In addition, the Fire Marshal reported that the hydrants have historically had problems with low flow and pressure levels and that neighboring areas were adequate.

Appendix A shows the layout of the existing streets and waterlines. This layout is a combination of the existing City records. Those records did not always agree as to street locations and pipe layout. The larger scale drawings were assumed to be more accurate. These drawings are not field-verified; they are for general use and should not be used for detailed information.

Table 4
Fireflow Tests Compared to the Calibrated Model

Test Location No.	Average Well Pressure (psi)										Tank Pressure (psi)				Fireflow Residual Pressure-psi		Fireflow (gpm)	
	Well 1		Well 2		Well 3		Well 4		Well 5		Tank 1		Tank 2					
	Test	Model	Test	Model	Test	Model	Test	Model	Test	Model	Test	Model	Test	Model	Test	Model	Test	Model
1	38	39	0	0	NA	37	29	29	40	40	36	35	<34	33	10	10	1,760	1,760
2	0	0	0	0	NA	32	40	40	40	40	35	35	<34	34	11	11	1,810	1,810
3	0	0	0	0	NA	33	40	40	40	40	35	35	<34	33	21	22	770	770
4	38	38	0	0	0	0	40	40	38	26	36	35	<34	33	18	18	2,280	2,280
5	0	0	43	43	0	0	40	40	40	40	36	37	<34	34	1	1	550	550
6	0	0	43	43	0	0	40	40	40	40	37	37	<34	34	11	11	550	550
7	0	0	41	41	0	0	40	40	40	40	34	34	<34	32	11	11	1,760	1,760

Test Locations:

1. Roosevelt and Valley Oak
2. Main and Grant
3. Apricot and Pear
4. Hemenway and Niemann
5. Railroad and Edwards
6. Second and Wolfskill
7. North End of Walnut

Notes:

1. When 0 psi is recorded for a well pressure, the well was not running during that test.
2. When NA is recorded for a well pressure, there was no pressure gage at that location.
3. Tank 2 has a shutoff valve that does not allow it to operate above 34 psi; it does not have an independent pressure gage to record actual pressure.
4. Fireflow tests were conducted during low demand conditions the morning of May 9, 1990.

EXISTING SYSTEM REPLACEMENT PROGRAM

The mainline pipe is quite old and is already beyond its expected service life. Galvanized portions of the system are suffering from galvanic corrosion rather then from age. The life expectancy of galvanized services and corporation stops connected to galvanically incompatible pipe is about 30 years. City staff estimates that a switch from brass to galvanized steel was made in the 1960s. Therefore, both mainline pipe and the galvanized parts of the system will need to be replaced in the future regardless of the alternative selected.

A regular replacement program for pipe older than 30 years should be implemented. Currently about 34,140 feet of pipe is over 30 years old. Existing 2- through 8-inch-diameter pipe should be replaced with a minimum 8-inch-diameter pipe. Pipe along Main Street should be replaced with 14-inch-diameter pipe. All other pipe larger than 8 inches should be replaced with pipe of the same diameter. New pipe should be a minimum of Class 150 PVC or ductile iron (see Appendix B). When the mainline is replaced, the adjacent service connections should also be replaced from the mainline to the face of curb. Polyethylene pipe, with a minimum class equal to a working pressure of 150 psi, and bronze corporation stops should be used for all service connections.

Order-of-magnitude replacement pipe costs are shown in Table 6 in the Cost Estimate section. To replace all of the pipe within the next 10 years, about 3,400 feet per year should be installed at a cost of approximately $377,000 per year.

Pipe that should be replaced during the first 3 years of the program is as follows:

- The 4- to 8-inch-diameter pipe along Edwards Street between Main and East Streets with 12-inch-diameter pipe

- The 2- and 4-inch-diameter pipe along Fourth Street between Grant Avenue and Russell Street with 12-inch-diameter pipe

- The 6-inch-diameter pipe along Walnut Lane between Grant Avenue and Dutton Street with 12-inch-diameter pipe

- The 4-inch-diameter pipe along Russell Street between the west end of Russell Street and Emery Street with 8-inch-diameter pipe

These improvements will add a main looped connection between the east and west sides of town to improve service throughout the downtown area and provide more pressure at the north end of Walnut Lane. They also eliminate approximately 6,900 feet of 80- to 100-year-old pipe.

The existing Well 1 should remain in service for the emergency demands of the City until either Well 6 is placed in service or Well 1 is replaced. Well 1 will need to be replaced in addition to Well 6 coming online to meet the future needs of the City.

In the interim, the present pump should be reinstalled with the bowls set at an elevation between 140 and 160 feet to reduce the likelihood of pumping oil. This places the pump in the well screen section of the casing, which is generally not a good practice. However, elevation 140 to 160 feet corresponds to a clay layer in the well log, which will partially decrease the likelihood of the pump pulling in sand from the surrounding area. The well is 38 years old and is approaching the end of its useful life. Therefore, setting the pump within the well screen carries a risk of causing deterioration of the well.

The exact location of the future replacement Well 1 is not critical as long as it is located in the eastern portion of the 20-year sphere of influence, adjacent to a mainline 12 inches in diameter or larger. The exact location will be determined by land availability and aquifer characteristics.

FUTURE SYSTEM ANALYSIS AND IMPROVEMENTS

CRITERIA FOR SIZING IMPROVEMENTS

Criteria used for sizing the future main water lines are based on maximum day demand plus the assumption of a fire occurring at the same time. This combined flow is the critical condition for each section of pipe when a fire is in its vicinity.

The number and size of wells and tanks are based on the condition that requires the most water throughout the entire system at one time. This is the peak-hour demand. In addition, the supply wells must be able to fully serve maximum day demands with no contributions from the largest well or storage tank.

Design criteria used for the City of Winters future water distribution system are summarized as follows:

Pressures:

- Maximum service pressure in new system = 60 psi
- Maximum service pressure in existing system = about 50 psi
- Minimum fireflow service pressure = 20 psi
- Minimum service pressure at peak-hour demand = 30 psi

Flows:

- Average daily demand in new system = 2,200 gpm
- Average daily demand in existing system = 1,010 gpm
- Maximum daily demand = 2.0 times average daily demand
- Peak-hour demand = 1.75 times maximum daily demand
- Fireflows = 1,500 gpm for residential; 2,000 gpm for commercial, and 3,000 gpm for industrial

System Design:

Use ductile iron or PVC pipe with minimum diameter of 8 inches. Place isolation valves and fire hydrants at a minimum spacing of the lesser of 300 feet or at each street crossing and 300 feet, respectively.

SYSTEM ALTERNATIVES

Two additional alternative water systems were evaluated for the City of Winters based on the design criteria listed above. One alternative evaluated use of a 2.5-million-gallon tank and the addition of one well. The other, evaluated installation of six new wells and maintenance of a two-pressure zone system.

RECOMMENDED IMPROVEMENTS

The recommended water system provides increased operating and fire flow pressures to the oldest existing areas of town in addition to flexibility and reliability for future growth. It is the most implementable in terms of facilitating phased installation of wells, which results in reduced initial capital outlays. This system can be easily modified by the addition of transmission pipe, storage tank, and booster pump to provide a future surface water supply.

EMERGENCY BACKUP

Each well should be equipped with a fixed standby generator to act as a backup power source. City staff have requested that generators be fueled with propane.

The telemetry system should also be equipped with a standby generator or battery backup to enhance consistency of operation of the water supply system.

TELEMETRY SYSTEM

A new telemetry system should be installed to monitor and efficiently operate the future system. The telemetry system would be composed of a central computerized unit and remote sensing devices at each well and the underground tank. The system could be operated from the central computer or from any well or tank in the system. The sensing devices at each remote location would monitor the flow from each well or tank, the pressure, the water level in the well, the frequency of the pump drive, and the chlorination system. The central computer can be programmed to automatically store the data and determine the peak-hour demand, maximum day demand, and a typical diurnal demand curve. This information will be needed to provide for correct sizing of water system components as the City continues to grow.

The communication device would be a leased telephone service with a continuous audible tone to provide more reliable service than the present phone telemetry system.

The computer system would automatically turn pumps off and on as the demand changes throughout the day, allowing them to operate more efficiently. The computer can also be set to force partial emptying of a tank so water in the tank does not stagnate.

The computer can signal by alarm or shut down part of the system if any of the following circumstances occur: the chlorinator tanks become low or fail to inject into the system, the water level drops below the level of the turbine bowls, the pump breaks down, the water level in the tank gets low, or the power goes off and the pumps go to standby generators. The system can be programmed to dial the operator's home phone number automatically during nighttime emergencies.

When the variable frequency drives are installed on Wells 2 and 3, and replacement Well 1, the wiring for the telemetry should be installed at the same time to minimize future installation costs for the telemetry system.

RECORDS

In addition to records currently maintained by the City, the following items should also be recorded:

1. Date of installation and location of new or replacement pipe, valves, and fire hydrants, and type and size of pipe and valves

2. PG&E pump test reports

3. Maintenance records of work done on each pump and well

When the new telemetry system is installed, it can automatically record the monthly well production from each well (currently done manually), the pressure, water levels, chlorine tank levels, peak hour flows, and maximum day flows.

COST ESTIMATES

Order-of-magnitude cost estimates were developed for each of the three alternatives. This type of estimate is expected to be accurate within +50 to -30 percent as defined by the American Association of Cost Engineers. The cost estimates were developed from cost curves, vendors, information obtained from previous studies, and CH2M HILL's experience on other projects.

The cost estimates have been prepared for guidance in evaluating the various options, from the information available at the time of the estimate. Final constructed cost of the project will depend on actual labor and material costs, competitive market conditions, final project scope, implementation schedule, and other variable factors. As a result, the final project costs will vary from the estimates presented here. Therefore, project feasibility and funding needs must be reviewed carefully prior to specific financial decisions to help ensure the proper choice of option and adequate funding.

A construction cost contingency allowance of 30 percent of the subtotal estimated construction cost was included based on suggested allowance factors presented by the American Society of Civil Engineers (ASCE). The 30 percent factor is recommended until more detailed engineering data are known. The resulting cost after application of the contingency allowance is the estimated construction cost.

Nondirect costs associated with engineering, construction management, administration, and legal costs, were included using a nondirect cost allowance of 20 percent of the construction cost. This allowance was also based on factors suggested by ASCE.

See Tables 5 and 6 for cost estimates. Costs are in March 1992 dollars.

WATER PIPE COSTS

The average unit cost of new pipe in developing areas is $4.20 per diameter inch per lineal foot of PVC Class 150 pressure pipe. This cost includes valves, fittings, hydrants, and complete installation in unimproved areas.

REPLACEMENT PIPE COSTS

Costs for the replacement program for the pipe are as follows: The unit cost includes excavation through pavement, removal of existing pipe, installation of new Class 150 pressure pipe, and paving 1 foot beyond each side of the trench. The cost includes valves, fittings, hydrants, and complete installation.

Table 5 Estimated Costs for Replacement Program				
Item	**Quantity**	**Unit**	**Unit Cost $**	**Estimate $**
8″ Pipe	18,700	lin ft	49	916,000
12″ Pipe	7,940	lin ft	75	596,000
14″ Pipe	7,300	lin ft	88	642,000
Service Connections	830	each	302	249,000
VFDs/Telemetry	2	each	41,000	82,000
Subtotal				**2,485,000**
Contingency (30%)				746,000
Subtotal				**3,231,000**
Engineering, Legal, and Administration (20%)				646,000
Total				3,877,000
Note: All items benefit the existing city.				

Table 6 Estimated Costs for Future System				
Item	**Quantity**	**Unit**	**Unit Cost $**	**Estimate $**
8″ Pipe	200	lin ft	34	7,000
10″ Pipe	19.700	lin ft	42	827,000
12″ Pipe	23.800	lin ft	50	1.190,000
14″ Pipe	38.500	lin ft	59	2.272.000
Wells[a]	4	each	245,000	980.000
Generators[b]	8	each	50,000	400,000
Telemetry System	1	each	50,000	50,000
Subtotal				**5,726,000**
Contingency (30%)				1,718,000
Subtotal				**7,444,000**
Engineering, Legal, and Administration (20%)				1,489,000
Total				**8,933,000**

[a]One of the four wells will replace existing Well 1, 47 percent of the cost for replacement of well is a benefit to new development.
[b]Three plus 47 percent at one generator ($173,500) is a benefit to new development.

WATER WELL COSTS

Water well costs are based on recent well construction projects in the area. Well costs assume a 600-foot-deep well capable of delivering 1,500 gpm. A depth of 600 feet was used based on the well log records for the City of Winters showing that wells drilled away from the influence of Putah Creek range from 500 to 600 feet deep. The well unit cost includes $175,000 for drilling, casing, gravel packing, well development, site acquisition, system connection, and power connection; $30,000 for a test hole to be drilled at each site; $15,000 for telemetry equipment; and $25,000 for each 1,500-gpm vertical turbine pump furnished and installed complete, for a total of $245,000 per well.

GENERATOR COSTS

Generators to supply standby power at well locations are estimated to cost $50,000 per unit.

TELEMETRY SYSTEM COSTS

A cost of $15,000 per telemetry station (wells) has been added to those features. An additional $50,000 is required for a base station at the City Corporation Yard.

VARIABLE FREQUENCY DRIVE COSTS

Wells 2 and 3, and replacement Well 1, should be retrofitted with variable frequency drives (VFDs). The associated telemetry equipment should be installed at the same time as the VFDs so that the telemetry system does not have to be retrofit later at a greater cost.

Wells 1 and 3 have 60-hp motors; Well 2 has a 100-hp motor. The estimated cost of VFDs for a 60-hp pump is $22,000 and $34,000 for the 100-hp pump. These costs include the variable frequency drive, an isolation transformer, and installation.

The VFD unit requires a 5-foot by 3-foot area near the pump. If the VFDs do not fit inside the existing pump enclosures, the cost will increase in order to house them in a separate or expanded building. The VFDs and pump must be compatible. If it is not possible to obtain compatible VFDs because of the age of the pumps, new pumps would be needed.

SERVICE CONNECTION COSTS

Service connection costs will average about $9 per lineal foot of pipe plus $32 per each connection for the corporation stop. The pipe cost includes saw cutting of pavement, trench excavation, bed zone material, backfill material, installation of pipe, and replacement of asphalt. The cost includes supplies and complete installation. If meter boxes are installed at the same time, there will be an additional cost of $100 for each connection. The costs in Table 6 do not include the meter boxes.

WELL 1 REPLACEMENT COSTS

The costs to replace Well 1 will be the same as the other water wells previously discussed, $245,000.

REFERENCES

Clark, John W., Warren Viessman, Jr., and Mark J. Hammer. *Water Supply and Pollution Control.* Third Edition. 1977.

Clovis, City of. *Water System Master Plan Update for Herndon/Shepherd Specific Plan.* May 1989.

Davis, City of. *Engineering Design Standards (Preliminary).* March 22, 1990.

Folsom, City of. *East Folsom Area Facilities Plan.* June 1988.

Lamont, Peter A. *Common Pipe Flow Formulas Compared with the Theory of Roughness.* May 1981.

Martin-Carpenter Associates. *Winters North Area Specific Plan.* December 1988.

Sharpe, Wayne W. and Thomas M. Walslei. *Predicting Internal Roughness in Water Mains.* November 1988.

Winters, City of. *General Plan.* Adopted May 1992.

Appendix A

EXISTING WATER SYSTEM

Appendix B

FUTURE WATER SYSTEM

Section 2
GROUNDWATER STUDY

Prepared for

CITY OF WINTERS

REGISTERED GEOLOGIST
ROBERT E. PEXTON
No. 4457
STATE OF CALIFORNIA

Robert E. Pexton

This Document Has Been Prepared Under the Direction
of a Registered Geologist

Prepared by

CH2M HILL
3840 Rosin Court, Suite 110
Sacramento, California 95834

May 7, 1992

SAC/T191/049.51

Section 2
GROUNDWATER STUDY CONTENTS

TABLES

FIGURES

INTRODUCTION

The City of Winters anticipates a large increase in population in the 20-year period between 1990 and 2010. The population as of the 1990 census is 4,693 and is expected to reach 12,500 by the year 2010. Most of this growth is expected north of the City between Dry Creek and Interstate 505. Water use in Winters in 1989-1990 was approximately 1,630 acre-feet per year (1,010 gallons per minute [gpm] average) (CH2M HILL, 1991a). This population growth will increase the City's projected water demand for the year 2010 to 5,180 acre-feet per year (3,210 gpm) for a population of 12,500 under the land use distribution of the General Plan (adopted in May 1992).

Groundwater is the sole water supply for the City of Winters. Five wells are used in Winters' 1990 distribution system. It is anticipated that groundwater will continue to be the water supply source for Winters and that additional water supply wells will be drilled to meet the increased demand as the population increases. This study evaluates groundwater for both the present (1990) and future (2010) conditions.

STUDY AREA

The City of Winters is located in Yolo County, California, along the north bank of Putah Creek about 30 miles west of Sacramento and 7 miles east (downstream) of Monticello Dam and Lake Berryessa. Winters is on the western edge of the Sacramento River Valley against the eastern edge of the Coast Range Mountains. The City is about 3 miles downstream of the Solano Diversion Dam on Putah Creek, which is part of the Solano Project that diverts most water from Lake Berryessa to the Putah South Canal to irrigate Solano County south of Winters.

The study area encompasses the 1,980-acre area within the City of Winters Urban Limit Line, which is located between Putah and Dry Creeks to the south and west, Interstate 505 to the east, and as far north as the City's existing wastewater treatment facility (Figure 1).

GEOLOGY

The City of Winters lies on the Putah plain, which has been constructed by Putah Creek as it switched courses and deposited sediment over a large area in the Pleistocene (10,000 to 2 million years ago) and recent (less than 10,000 years) time. The U.S. Geological Survey (Thomasson, 1960) studied the geology and hydrology of the region and divided the subsurface lithology into the units described below.

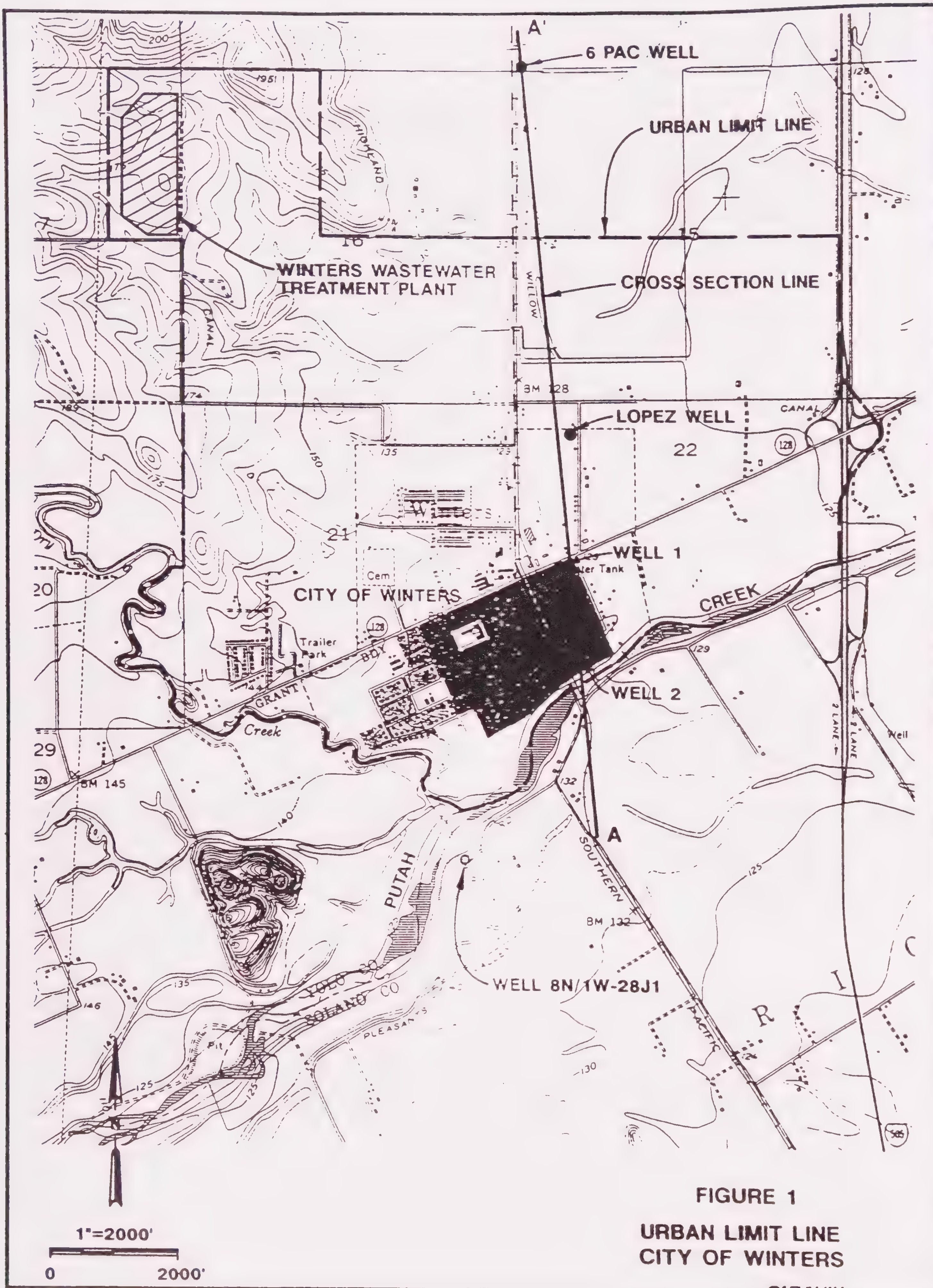


FIGURE 1

URBAN LIMIT LINE
CITY OF WINTERS

CH2M HILL

Stream channel deposits of recent age occur primarily along the incised channel of Putah Creek, approximately 30 feet below Winters' city street level. Stream channel deposits consist of loose coarse sand and gravel and are, in part, actively shifting and moving downstream. They are highly permeable but are of limited thickness (0 to 10 feet) and extent, and they are not important for water supply except as a groundwater recharge area. The recent stream channel deposits also occur as fine-grained overbank flood deposits which were deposited when Putah Creek overflowed its banks.

The Younger Alluvium underlies the overbank stream channel deposits and ranges from 0 to 40 feet thick. It consists of loose grayish brown silt and fine-grained sand with some silty clay and medium- to coarse-grained sand and gravel. The Younger Alluvium is moderately permeable but is generally above the water table. Most of it readily transmits water down to the water table.

The Older Alluvium of Pleistocene age underlies the Younger Alluvium and ranges from 0 to 150 feet thick. It consists of stream-deposited silt, silty clay, gravel, and sand. It is flat-lying, predominantly fine-grained, and ranges from loose to moderately compacted. About one-fourth of it is gravel and sand, which occur as lenses rather than continuous sheets. The thickness ranges from 60 to 130 feet through most of the Putah plain. The hydraulic conductivity is extremely variable, averaging 3,000 to 4,500 gallons per day (gpd) per square foot for sand and gravel aquifers near Winters (Thomasson, 1960).

An angular conformity separates the underlying eastward dipping Tehama Formation from the flat-lying Older Alluvium. The Tehama consists of fluvial (stream-deposited) and lacustrine (lake-deposited) sediments of Pleistocene and Pliocene (2 million to 5 million years ago) age. Moderately compacted silt, clay, and silty fine sand-enclosed lenses of sand and gravel and calcium carbonate cemented conglomerate. The subsurface contact with the Older Alluvium is not well-defined in many places and may be gradational beneath much of the Putah plain where the Tehama ranges from 1,500 to 2,500 feet thick.

The permeability of the Tehama is highly variable. The gravel and sand aquifers are generally less permeable than the Older Alluvium. Locally, aquifers in the Tehama yield large quantities of water, and most wells producing over 1,000 gpm in the Putah area tap both the Older Alluvium and the Tehama (Thomasson, 1960).

Figure 2, a north-south cross section noted as line A-A' in Figure 1, is constructed from boring logs of City of Winters Wells 1 and 2, the Lopez well, and a well at Six Pac Industries, located on Railroad Avenue north of the Urban Limit Line.

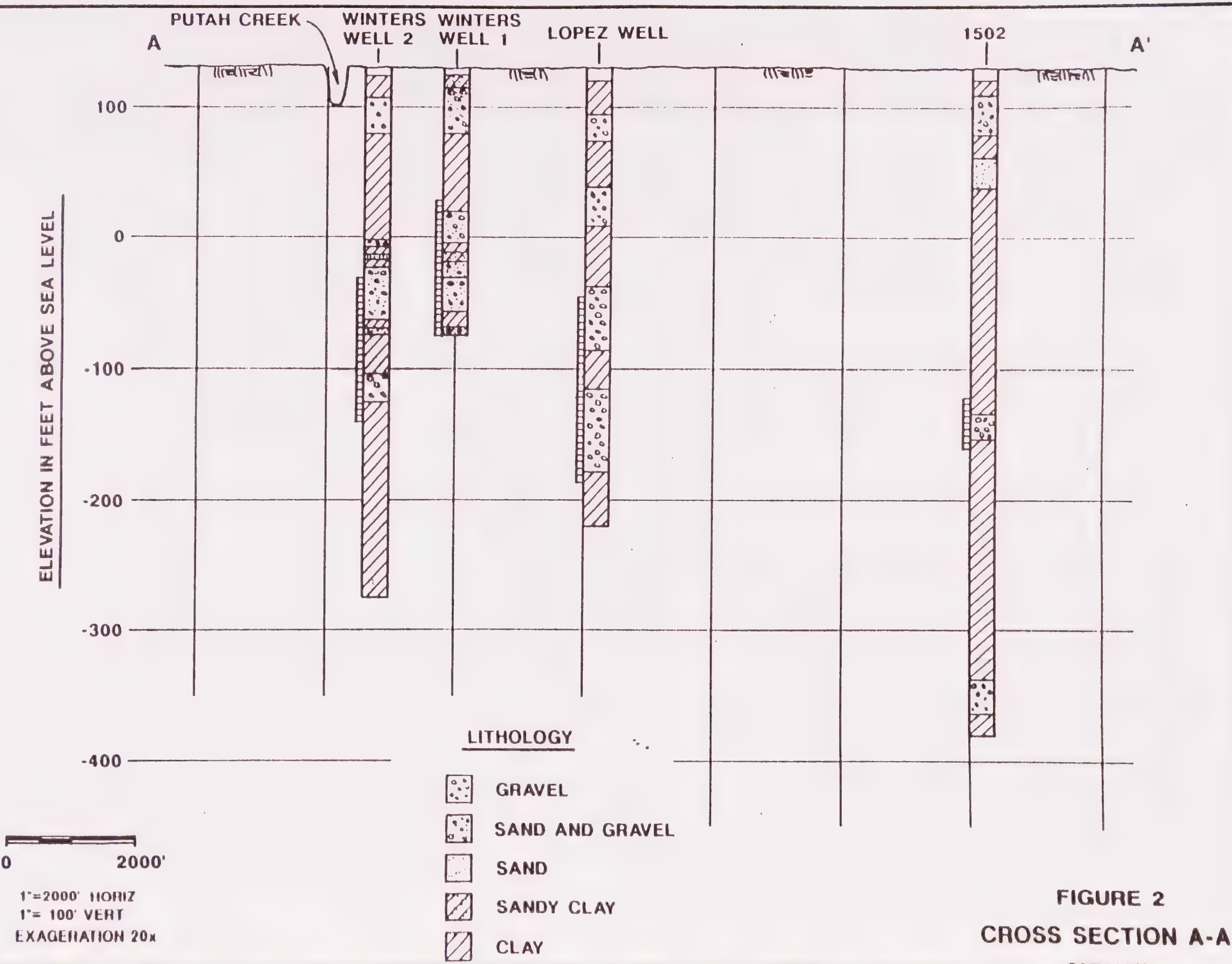


FIGURE 2
CROSS SECTION A-A'

CH2M HILL

GROUNDWATER HYDROLOGY

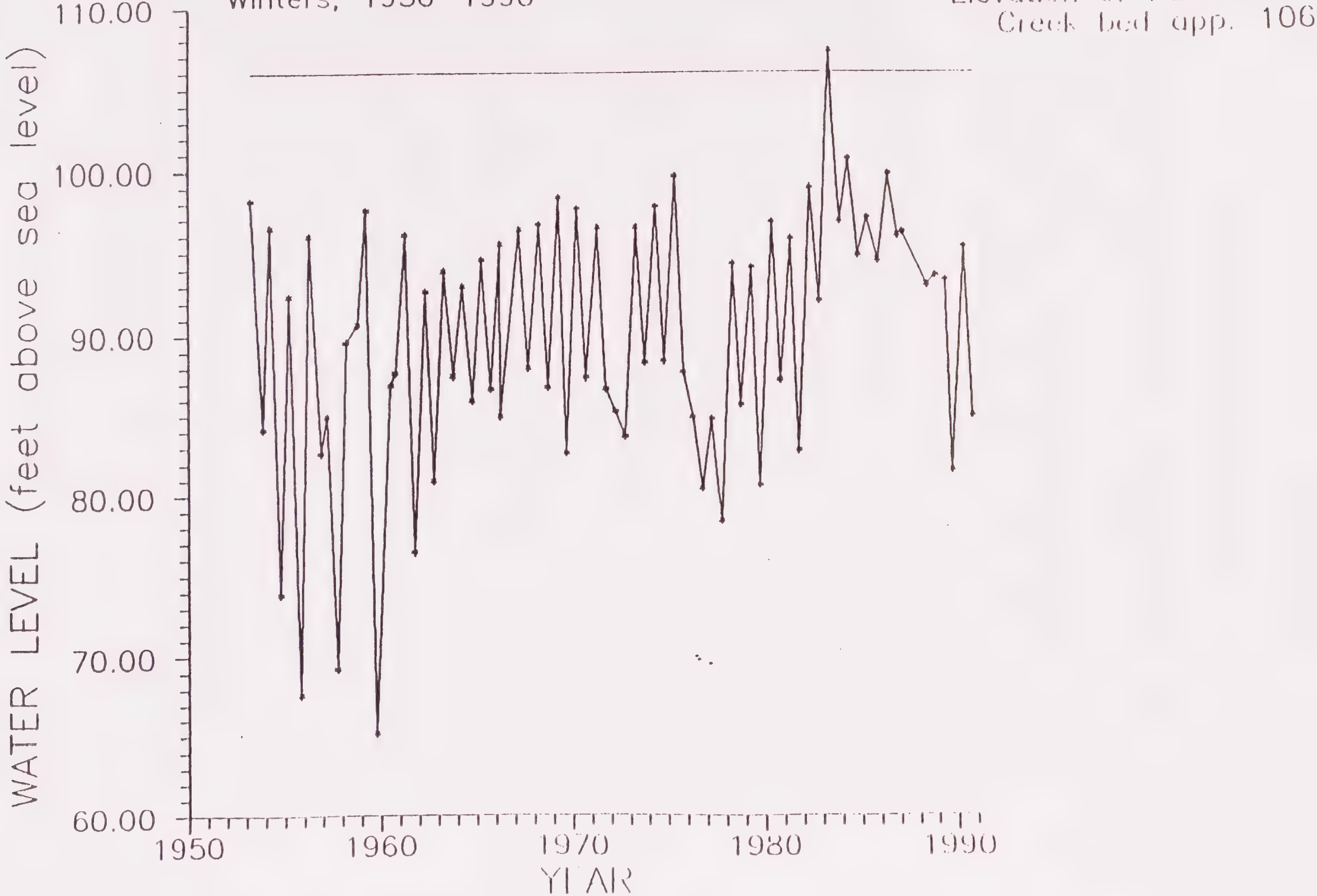
Groundwater levels in the vicinity of Winters fluctuate seasonally with high levels occurring in spring and lowest levels occurring in fall; after the dry summer season, during which the vast majority of agricultural pumping occurs. The long-term water level trend is stable in the Winters area, as shown in Figure 3. Other wells in the vicinity of Winters measured by the California Department of Water Resources (DWR) show a similar trend. This indicates that there has not been a long-term groundwater overdraft in the vicinity of Winters. Groundwater levels are almost always below Putah Creek, averaging about 15 feet below the creekbed elevation of 106 feet near the well graphed on Figure 3.

A groundwater elevation map for the spring of 1985 (Figure 4) developed for the Solano Project by the U. S. Bureau of Reclamation (USBR, 1985) shows groundwater flowing roughly west to east in the immediate vicinity of Winters. The groundwater gradient is approximately 5 feet in 4,000 feet, or 0.0013. The groundwater elevation and gradient vary with drought cycles and changing demands for agricultural groundwater pumping.

Putah Creek is a significant source of recharge to groundwater in the Winters area (Thomasson, 1960). Putah Creek acts as a losing stream near Winters, which will recharge the groundwater by infiltration of surface water. If groundwater levels rise to a level higher than Putah Creek, as in 1986 (Figure 3), Putah Creek will act as a gaining stream in which recharge is rejected and Putah Creek will instead act as a discharge point for groundwater.

DWR (1978) evaluated groundwater storage capacity and change in storage for the Sacramento Valley for the period 1961 to 1970. The DWR study divided the Sacramento Valley into a series of four township blocks in the valley. The block that includes Winters (Township 7 north and Range 1 west of the Mount Diablo baseline and meridian T7N, R1W) consists of T7 and 8N, R1E, and the eastern part of R1W. In this 50,200-acre area bordered by the Coast Ranges west of Winters, average annual groundwater pumpage was 32,700 acre-feet for 1961 to 1970. Average annual total recharge was 38,400 acre-feet, which consisted of 9,900 acre-feet from infiltration of applied water (30 percent of applied water recharged the groundwater), approximately 8,500 acre-feet of recharge from precipitation (10 percent of precipitation recharged the groundwater), and about 20,000 acre-feet of recharge from the approximately 10-mile-long stretch of Putah Creek within the 50,200-acre area. Subtracting the 32,700-acre-foot average annual groundwater pumping from the 38,400-acre-foot average annual recharge gave a net average annual increase in groundwater storage for this area of 5,700 acre-feet for 1961 to 1970. Assuming the recharge is proportional to the area, then the 1,980-acre area within the Urban Limit Line would have had a net average annual increase in groundwater storage of about 220 acre-feet.

Figure 3. Water levels from well 8N/1W-28J1 located 50 feet south of south bank of Putah Creek across from Winters, 1950-1990



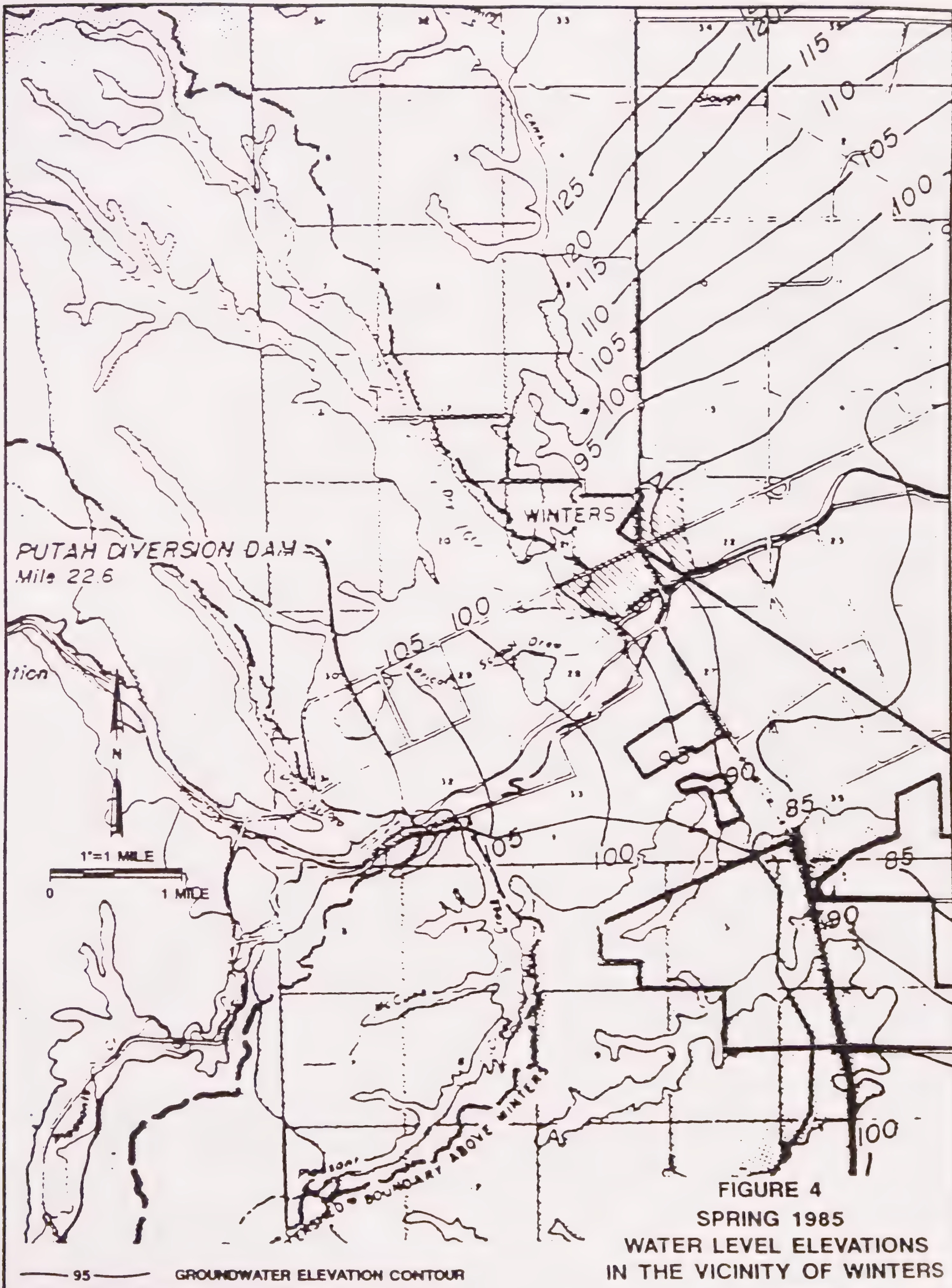


FIGURE 4
SPRING 1985
WATER LEVEL ELEVATIONS
IN THE VICINITY OF WINTERS

—— 95 —— GROUNDWATER ELEVATION CONTOUR

SOURCE: USBR SOLANO PROJECT 1985

CH2M HILL

Groundwater storage was evaluated to a depth of 600 feet based on 1965 groundwater levels in the DWR study (DWR, 1978) using a computer program. DWR is updating this study; however, results are not presently available. DWR (1978) reported a total storage of 1,272,000 acre-feet within the four-township (50,200-acre) block that includes Winters. Assuming storage within the 1,980-acre Winters study area is proportional to storage in the 50,200-acre area studied by DWR, a total of 50,000 acre-feet of groundwater is stored to a depth of 600 feet under the Winters area bounded by the Urban Limit Line. The average amounts of groundwater storage under the Winters area bounded by the Urban Limit Line study area (assuming it is proportional to the 50,200-acre block) to a depth of 600 feet, the maximum well depths in the area are as follows:

- 4,400 acre-feet from 20 to 100 feet below ground surface
- 10,000 acre-feet from 100 to 200 feet above ground surface
- 9,600 acre-feet from 200 to 300 feet above ground surface
- 9,000 acre-feet from 300 to 400 feet above ground surface
- 9,500 acre-feet from 400 to 500 feet above ground surface
- 7,500 acre-feet from 500 to 600 feet above ground surface

GROUNDWATER QUALITY

Groundwater in the region surrounding Winters generally has decreasing total dissolved solids (TDS), hardness, and chloride concentrations with increasing depth in the aquifer (Clendennon, 1976). Groundwater quality parameters are given in Table 1 for wells in the vicinity of Winters for 1931, the period 1960-69, and 1970 (Clendennon, 1976) and for City of Winters wells in 1990 (City of Winters, 1990). Clendennon (1976) evaluated groundwater quality for both the shallow (0- to 200-foot depth) and intermediate (200- to 400-foot depth) zones for the period 1960 to 1969 (Table 1). Total dissolved solids were below the secondary drinking water standard of 500 milligrams per liter (mg/l) in both the shallow (380 mg/l) and intermediate (370 mg/l) zones. Chloride concentrations were below the 250-mg/l secondary standard averaging 31 mg/l in the shallow and 15 mg/l in the intermediate zones. Nitrate concentrations rarely exceeded 10 mg/l, well below the 45-mg/l standard as nitrate. Hardness levels were (250 mg/l in the shallow and 250 mg/l in the intermediate zones, which is too high for industrial uses unless softened). City of Winters records for 1990 show similar levels for groundwater quality parameters (Table 1). Water quality conditions have not varied significantly in the past 60 years, although the nitrate concentration of 18 mg/l in City wells in 1990 is higher than historic levels.

The aquifer under the area bounded by the Urban Limit Line is significantly recharged by Putah Creek (Thomasson, 1960; DWR, 1978), which has good quality water. Clendennon (1976) reported average TDS of 210 mg/l, chloride of 5.7 mg/l, boron of 0.16 mg/l, and negligible nitrate for Putah Creek water.

Table 1 Groundwater Quality in the Winters Area					
Date	**Depth Range**	**Total Dissolved Solids (mg/l)**	**Hardness (mg/l)**	**Chloride (mg/l)**	**Nitrates (mg/l)**
1931	Shallow	390	312	17	8
1931	Intermediate	360	273	18	9
1960-69	Shallow	380	282	31	5.8
1960-69	Intermediate	370	260	15	10
1970	Shallow	382	284	32	6
1970	Intermediate	374	265	16	10.5
1990	City wells	352	315	22	18

The depth of the fresh groundwater underlying Winters is about 2,000 feet (DWR, 1978). Below that depth, groundwater is saline connate water from the deposition of Eocene sediments when the Central Valley was an inland sea. This deep saline water should not affect drinking or irrigation water supplies.

CITY OF WINTERS GROUNDWATER BUDGET

A groundwater budget has been developed both for present (1990) and future (2010) conditions. The budget, presented in Table 2, sums the input due to recharge and output due to discharge for the part of the groundwater basin that underlies the area bounded by the Urban Limit Line. The components of and assumptions used for the budget are described in the following text. The amounts of water for each item are estimated in the text to the nearest acre-foot and are rounded to two significant figures to reflect the uncertainty in the estimates in Table 2.

Table 2 Groundwater Budget for City of Winters in 2010		
	Present Conditions (1990 in ac-ft)	**Future Conditions (2010 in ac-ft)**
RECHARGE		
Subsurface inflow	1,500	1,500
Deep percolation of precipitation	350	390
Seepage from Putah Creek	2,200	2,600
Seepage from Dry Creek	100	100
Deep percolation from applied ag irrigation	750	70
Deep percolation from landscape irrigation	270	950
Deep percolation from sewage treatment plant	390	250
Total recharge	**5,600**	**5,860**
DISCHARGE		
Subsurface outflow	1,600	450
Agricultural pumpage	2,260	230
M&I pumpage	1,630	5,180
Seepage, discharge to Putah Creek	0	0
Total discharge	**5,600**	**5,860**

The governing equation for a groundwater water balance is:

Discharge - Recharge = Change in Storage

RECHARGE

1. *Subsurface Inflow*

This can be estimated for the year 2010 for the City of Winters using the following form of Darcy's Law.

$$Q = T\,i\,L$$

Where:

Q = Groundwater inflow to the area.

T = Transmissivity in gallons per day per foot based on specific capacity tests of representative wells in the area. Multiplying the typical specific capacity of 50 gpm per foot of drawdown by 2,000 (a standard conversion for wells in the Central Valley of California) gives an average transmissivity of 100,000 gallons per day per foot.

i = Groundwater gradient in feet of vertical drop per foot of horizontal distance, measured to be about 0.0013 in the study area.

L = Effective width of flow, estimated to be about 10,000 feet along the western border of the area bounded by the Urban Limit Line (Figure 1).

Solving for Q gives:

Q = (100,000 gallons/day/ft)(0.0013)(10,000)

= 1,300,000 gallons/day

= 1,500 acre-feet/year

The average inflow to the area bounded by the Urban Limit Line should be the same for both 1990 and 2010 assuming upgradient withdrawals do not change significantly during this period.

2. *Deep Percolation of Precipitation*

The area within the City of Winters Urban Limit Line is currently approximately 495 acres of developed municipal and industrial (M&I) land and 1,485 acres of agricultural land. Average rainfall in Winters is 20.4 inches (1.7 feet) per year (CH2M HILL, 1991). Approximately 12 percent of precipitation on M&I land becomes groundwater recharge (CH2M HILL, 1990) for 101 acre-feet per year of groundwater recharge from precipitation on M&I land. Approximately 10 percent of precipitation on agricultural land is deep percolation (CH2M HILL, 1990) that becomes groundwater recharge, which gives 252 acre-feet per year of recharge from precipitation on agricultural land. The total groundwater recharge from precipitation on the M&I plus agricultural land totals 353 acre-feet.

In the year 2010, 1,865 acres are expected to be M&I land, which, at 12 percent deep percolation, gives 380 acre-feet of groundwater recharge per year. Seventy-six acres are expected to remain agricultural land, which at 10 percent deep percolation, gives 13 acre-feet of recharge per year. Total recharge in 2010 is expected to be 393 acre-feet.

3. *Seepage from Putah Creek*

The recharge from a stream to the groundwater basin is dependent on several factors: (1) the amount of flow in the stream and the length of time it is flowing, (2) the permeability of the streambed and the wetted area of the streambed, and (3) the difference between the stream level and the level of the groundwater table and whether they are coupled (connected). If the stream is coupled with the groundwater, the recharge is proportional to the slope between the stream level and the groundwater table. However, if the stream is decoupled or separated from the groundwater below, water infiltrates vertically through the streambed and underlying sediments at a constant rate for a given volume of water in the stream. This rate would not increase with a lowering of the groundwater (groundwater would be decoupled from the stream). Putah Creek is probably coupled with the underlying groundwater basin most of the time, but this needs to be evaluated.

Infiltration from Putah Creek on the south boundary of Winters is high due to the creekbed being in good communication with the Older Alluvium, the principal regional aquifer (Thomasson, 1960). Before construction of the Monticello Dam 7.4 miles west (upstream) of Winters in 1957, the total flow in Putah Creek averaged over 350,000 acre-feet per year (for the period 1906 to 1931) as measured at a gaging station just below the railroad bridge at the town of Winters (Thomasson, 1960). In the 1950s, before construction of the Monticello Dam, recharge was measured to be about 15 cubic feet per second (cfs) in the approximately 19,000-foot-long stretch from the location of the Solano Diversion Dam to Interstate 505. This recharge rate was higher at the beginning of a flow season, as a groundwater mound was built up under the creekbed, and was lower during periods of sustained high flow and high groundwater levels, when some recharge would be rejected. Very high infiltration rates of 40 cfs were recorded for a week in January 1931 (Thomasson, 1960). However, the rate for the second week of January 1931 dropped to 12 cfs.

Since construction of the Monticello Dam, releases have been controlled within narrow ranges. Most water released from Monticello Dam is diverted to the Putah South Canal at the Solano Diversion Dam located 3.3 miles upstream from Winters. Average diversions are just over 200,000 acre-feet per year. Releases from the Solano Diversion Dam are 22,500 acre-feet during normal

years and 19,000 acre-feet during dry years. Much larger releases have occurred in exceptionally wet years such as 1983. In the 1970s, flow below the dam ranged from 20,000 to 25,000 acre-feet per year (USGS, 1980).

Recharge from Putah Creek in the interval from the Solano Diversion Dam upstream of Winters to Interstate 505 on the east edge of the Urban Limit Line averaged 11 to 15 cfs from September 1990 to January 1991 during low flow releases of about 25 cfs from the Solano Diversion Dam (Yates, 1991). Recharge rates may be somewhat flow-dependent, as a short-duration 100-cfs release from the Solano Diversion Dam in September 1990 resulted in 40 cfs infiltration from the dam to Interstate 505 (Yates, 1991). Recharge may be higher than 15 cfs during normal year releases.

Using an average value of 15 cfs, 10,900 acre-feet per year is recharged. The stretch of Putah Creek along the southern boundary of the area bounded by the Urban Limit Line is approximately 7,000 feet long. Assuming recharge is proportional to the length of the creekbed, approximately 6 cfs or 4,340 acre-feet downstream of the Solano Diversion Dam is recharged. Approximately half of this recharge will go to the north and south of the creek as the groundwater generally flows east-west in the immediate vicinity of Winters. Thus, about 2,170 acre-feet rounded to 2,200 acre-feet is recharged to the area within the Urban Limit Line from Putah Creek under 1990 conditions.

As a result of the drought, groundwater levels in 1990 were at relatively low levels. Therefore, the gradient between Putah Creek and the groundwater basin it is recharging is relatively steep. It is not likely that the groundwater levels in 2010 will be lower than 1990 levels; therefore, the gradient-dependent portion of recharge from Putah Creek is not likely to be higher than the 15 cfs measured in 1990-91; unless average flows below the Solano Diversion Dam are increased to levels above the dry year release rates of 19,000 acre-feet per year, on which the 15-cfs recharge rates were based. If recharge rates are proportional to flow in Putah Creek, a normal release of 22,500 acre-feet per year (compared to the dry year release of 19,000 acre-feet per year) will give about 2,600 acre-feet of recharge under 2010 conditions.

Infiltration from Putah Creek is the largest single component of recharge to the groundwater basin in the vicinity of Winters and it is not well-known. Frequent measurements of Putah Creek flows and infiltration rates from the Solano Diversion Dam to Interstate 505 at the downstream (western) boundary of the Urban Limit Line are needed to accurately evaluate the long-term recharge rates from Putah Creek.

4. *Seepage from Dry Creek*

Dry Creek, an ephemeral creek, flows along the southwest boundary of the Winters Urban Limit Line and discharges to Putah Creek. Seepage has not been measured. Dry Creek is about 48,000 feet long and about 6,000 feet, or one-eighth the length of Dry Creek, borders the southeast edge of the Winters Urban Limit Line. The watershed for Dry Creek is approximately 16 square miles, or 10,240 acres. Assuming that 10 percent of the 20.4-inch annual rainfall in the watershed runs off as overland flow into Dry Creek and half of the flow in Dry Creek infiltrates to groundwater through the gravelly creekbed, approximately 100 acre-feet is recharged to the 6,000-foot stretch of Dry Creek bordering the Winters Urban Limit Line. Recharge would be about the same for both 1990 and 2010 conditions.

5. *Deep Percolation from Applied Agricultural Irrigation Water*

Planimetry work on a 1990 airphoto indicated there were 225 acres of orchards, plus 515 acres of irrigated fields for 740 acres of agriculture, within the Urban Limit Line. The cropping pattern for 1990 is based on 1990 registered pesticide use (Yolo County Agriculture Dept., 1991) and aerial photographs. A total of 818 acres of crops reported pesticide use to Yolo County (Yolo County, 1991) from Sections 15, 16, 21, and 22 of T8N, R1W (Figure 1). The northern half of Sections 15 and 16 are not included within the Winters Urban Limit Line (Figure 1). Department of Water Resources values (1990) for applied water requirements are used to estimate the amount of water applied.

The average amount of water applied for 1990 agricultural irrigation in Sections 15, 16, 21, and 22 of T8N. R1W was 3.5 acre-feet per acre for the 225 acres of orchards for 787 acre-feet of water applied to the orchards, and 3.1 acre-feet per acre for the 515 acres of field crops for 1,596 acre-feet of water applied to the field crops. Adding the orchards and field crops gives 2,380 acre-feet of applied agricultural water for 1990 within the Winters Urban Limit Line.

Assuming ½-mile furrow medium management irrigation is used for the 515 acres of field or row crops, 32 percent (CH2M HILL, 1990) of the 3.1 acre-feet per acre of applied water becomes groundwater recharge, which gives 510 acre-feet per year of recharge. Assuming border medium management irrigation is used for the 225 acres of orchards, 30 percent (CH2M HILL, 1990) of the 3.5 acre-feet per acre of applied water becomes groundwater recharge, which gives 240 acre-feet per year of recharge. The total recharge from applied irrigation water under 1990 conditions is 750 acre-feet per year.

All but 76 acres within the Winters Urban Limit Line are planned to be converted to municipal and industrial use in 2010. Agricultural water demand is projected to be 230 acre-feet per year for this land. Approximately 32 percent,

or 74 acre-feet, will be recharged from irrigating field crops on this land in 2010. If this land is left fallow in 2010, agricultural pumpage will drop by 230 acre-feet per year and recharge will drop by 74 acre-feet.

6. *Deep Percolation from Water Applied for Landscape Irrigation*

As of 1990, the average Winters municipal water pumping is about 1,630 acre-feet per year. Wastewater flow to the sewage treatment plant is about 0.55 million gallons per day (mgd) or 616 acre-feet per year (about 38 percent of total pumped groundwater). The difference between these figures is 1,014 acre-feet per year, which is likely used for landscape irrigation. Approximately 27 percent of this percolates to groundwater (assuming recharge rates comparable to movable hand sprinkler irrigation [CH2M HILL, 1990]), which gives 270 acre-feet of recharge for 1990.

The estimated municipal and industrial water demand within the Urban Limit Line in 2010 is 5,180 acre-feet per year for a population of 12,500. Predicted average annual wastewater influent for 2010 is 1.5 mgd (about 33 percent of total water) or 1,680 acre-feet per year (CH2M HILL, 1991a). The amount of water available for landscape irrigation will increase to 3,500 acre-feet per year. Assuming 27 percent of this water becomes groundwater recharge, using hand sprinkler irrigation recharge rates (CH2M HILL, 1990) gives 945 acre-feet of recharge from applied landscape irrigation water in 2010. It is likely that landscape irrigation efficiency will increase in the future and a smaller amount of water will be applied and a smaller amount will deep percolate to become groundwater recharge.

7. *Percolation from Sewage Treatment Plant Operations*

The sewage treatment plant on the northern boundary of the Winters SOI has 28.6 acres of ponds that contribute some recharge to groundwater through infiltration. Treated wastewater is applied to agricultural land east of the ponds as well. The plant receives approximately 0.55 mgd of influent or 616 acre-feet per year. Pond evaporation is 58 inches or 4.83 feet per year (CH2M HILL, 1991a). Multiplying 28.6 acres of ponds by 4.83 feet of evaporation gives 138 acre-feet of evaporation per year; 124 acre-feet of treated effluent is applied to land east of the ponds according to City of Winters records. Subtracting evaporation and effluent from influent gives 354 acre-feet of infiltration from the ponds to recharge groundwater.

Approximately 27 percent (assuming movable hand sprinkler recharge rates [CH2M HILL, 1990]) of the 124 acre-feet of treated effluent applied to land east of the ponds will infiltrate to groundwater, giving about 33 acre-feet per year of recharge. The total groundwater recharge from sewage treatment plant operations under 1990 conditions is about 387 acre-feet.

The preferred alternative for sewage treatment in 2010 from the Winters Water System Master Plan (CH2M HILL, 1991a) is to treat wastewater to at least secondary level and apply the treated water for irrigation in the summer and discharge treated water to Putah Creek in the winter. Pond effluent can be calculated by taking pond influent 1.5 mgd (1,680 acre-feet per year) and subtracting 58 inches annual evaporation from the 10 acres of ponds (48 acre-feet), subtracting the 26 inches annual estimated percolation from the 10 acres of ponds (22 acre-feet), and adding the 20 inches annual rainfall to the ponds (17 acre-feet) to give 1,630 acre-feet of annual effluent from the treatment plant. It is anticipated that about 850 acre-feet will be available for golf course or agricultural irrigation and 780 acre-feet will be discharged to Putah Creek in the winter. Assuming 27 percent of the 850 acre-feet of treated effluent used for irrigation is recharged, the recharge will be 230 acre-feet. Adding the 22 acre-feet of estimated percolation from the 10 acres of ponds gives a total of 250 acre-feet of recharge from sewage treatment plant operations in 2010.

Projected water requirement for the golf course planned to be located near the sewage treatment plant is 720 acre-feet, which would leave 130 acre-feet available for other uses. Additional irrigation water could be made available by building more ponds at the treatment plant to store the treated effluent in the winter rather than discharging it to Putah Creek.

DISCHARGE

1. *Subsurface Outflow*

Subsurface outflow under 1990 conditions is about 1,600 acre-feet per year. Subsurface outflow will probably decrease dramatically due to the net increase in water consumption by 2010.

2. *Agricultural Pumpage*

Approximately 2,380 acre-feet of irrigation water was applied within the Winters Urban Limit Line in 1990 as noted above. In 1989, the last year surface water was available, the only surface water delivered was 120 acre-feet of surface water delivered to Yolana Farms from the Willow Canal according to the Yolo Country Flood Control and Water Conservation District (YCFCWCD, 1991). Subtracting surface water from required irrigation water gives about 2,260 acre-feet of groundwater pumped within the Winters Urban Limit Line under 1990 base year conditions. Most of the land in the western part of Sections 16 and 21 (Figure 1) is currently fallow and presumably does not have any groundwater pumped from it.

In 2010 all but 76 acres of land is assumed to be converted to municipal and industrial uses and agricultural groundwater demand will be 230 acre-feet.

3. *Municipal and Industrial Pumping*

The 1990 base pumping for Winters is 1,630 acre-feet per year. Estimated M&I groundwater required for Winters in 2010 for a population of 12,500 is 5,180 acre-feet per year.

4. *Seepage or Discharge to Putah Creek*

Putah Creek is a losing stream which recharges the water table in the vicinity of Winters. When groundwater levels are exceptionally high, such as the spring of 1986, some recharge would be rejected. Groundwater is not expected to discharge to Putah Creek under average conditions. For a population of 12,500, approximately 780 acre-feet of treated wastewater effluent will be discharged to Putah Creek during the winter months.

SUMMARY

Groundwater recharge and discharge within the Winters 1,980-acre Urban Limit Line appear to be in balance under 1990 conditions. Total groundwater withdrawal of approximately 3,900 acre-feet is approximately equal to the total recharge occurring within the year 2010 (not including subsurface inflow).

Increases in water demand for Winters in 2010 will entail a net projected increase in total groundwater pumping of about 1,500 acre-feet per year to 5,410 acre-feet per year (M&I and agricultural pumpage) for a population of 12,500 in the year 2010. The farmland in the eastern part of the area bounded by the Urban Limit Line, which is irrigated nearly entirely by groundwater, will not have a large change in water demand when converted to municipal and industrial uses, as the amount of water required is approximately the same in either case. The land in the northwestern part of land bounded by the Urban Limit Line is presently fallow, unirrigated land. Converting this land to municipal use will increase water demand.

Pumping groundwater to meet this increased demand may induce some increased recharge from Putah Creek, provided there is sufficient flow in the creek, and will also reduce groundwater outflow from the area within the Urban Limit Line. It is recommended that groundwater levels be carefully monitored during the next 20 years to determine if a progressive long-term decline in water levels occurs. Water level measurements should be made in the fall and spring at a minimum in conjunction with the DWR monitoring program. Flow rates and infiltration from Putah Creek also need to be measured to evaluate actual long-term recharge rates to the groundwater basin from Putah Creek.

If groundwater levels are found to be dropping, the maximum water conservation plan that has 29 percent water savings projected can be implemented. Water savings of 29 percent equates to a net decrease in groundwater pumping of 1,570 acre-feet (29 percent of 5,410), which would reduce total pumping demand to 3,840 acre-feet. This is less than the groundwater recharge currently occurring within the area bounded by the Urban Limit Line and would actually decrease overall groundwater demand below 1990 conditions.

REFERENCES

California Department of Water Resources. 1975. *Vegetative Water Use in California, 1974*. Bulletin 113-3.

__________. 1978. *Evaluation of Ground Water Resources: Sacramento Valley*. Bulletin 118-6.

__________. 1986. *Elevation of Water in Wells, Sacramento Valley, California*.

CH2M HILL. 1990. *Irrigation System Costs and Performance in the San Luis Unit, California*.

__________. 1991a. *Water System Master Plan* Prepared for City of Winters.

__________. 1991b. *Storm Drain Master Plan* prepared for the City of Winters.

Clendennon & Associates. 1976. *Yolo County Groundwater Study*.

__________. 1990. McGuire, R. A. Personal Communication. California Department of Water Resources. Cropping Pattern Data and Applied Water Requirements for the Winters Quadrangle, California.

Olmstead, F. H., and G. H. Davis. 1961. *Geologic Features and Ground-Water Storage Capacity of the Sacramento Valley, California*. U.S. Geological Survey Water-Supply Paper 1497.

Thomasson, H. G., F. H. Olmstead, and E. F. LeRoux. 1960. *Geology, Water Resources and Usable Ground-Water Storage Capacity of Part of Solano County, California*. U.S. Geological Survey Water Supply Paper 1464.

U.S. Department of the Interior, Bureau of Reclamation, Mid-Pacific Region. 1988. *Draft Environmental Impact Statement Technical Appendix A, CVP Water Contracting Programs*. December.

U.S. Department of the Interior, Bureau of Reclamation. Solano Project, California, Water Rights Investigation-Putah Creek, Groundwater level maps for 1960, 1970, 1975, 1980, and 1985.

U.S. Geological Survey (USGS). 1971-1980. Water Resources Data, California Water Years 1971 to 1980.

City of Winters. 1990. Water Quality Report.

Yates, E. U.S. Geological Survey, Sacramento, California. Personal Communication. January 1991.

Yolo County Agriculture Department. 1991. Personal Communication from Teresa Sanchez-Adams. Agricultural Use Near Winters.

Yolo County Flood Control and Water Conservation District. 1991. Parcel Water Usage Listing-Surface Water, 1989.

Section 3
URBAN WATER MANAGEMENT PLAN

Prepared for

CITY OF WINTERS

Prepared by

CH2M HILL

3840 Rosin Court, Suite 110
Sacramento, California 95834

May 8, 1992

SAC/T166/052.51

Section 3
URBAN WATER MANAGEMENT PLAN CONTENTS

Page

APPENDIXES

TABLES

FIGURES

EXECUTIVE SUMMARY

Three alternative water conservation programs for the City of Winters were identified and evaluated on basis of water savings and economic feasibility. The first, a Moderate program, examined conservation measures that could be implemented by the City with minimum disruption to the lifestyles of current residents and at minimum costs. The measures composing the Moderate program include:

- Low-flow plumbing ordinance for new construction
- Retrofit of low-flow plumbing fixtures as older fixtures wear out
- Alternate-day, odd/even outdoor watering schedule
- Public education and a "water waster" ordinance
- Metering of new construction
- Meter retrofit of existing structures in conjunction with main replacement

The second program, termed Aggressive, builds upon the Moderate program and adds the following measures:

- Plumbing retrofit and water audits of selected residential housing and businesses

- Landscape ordinance for multi-family housing and businesses

- Additional public educational measures and a "bounty" program for reporting water wasters

The third, the Maximum program, achieves more water savings than the previous two, but at a higher initial cost. Additional measures imposed by this program include:

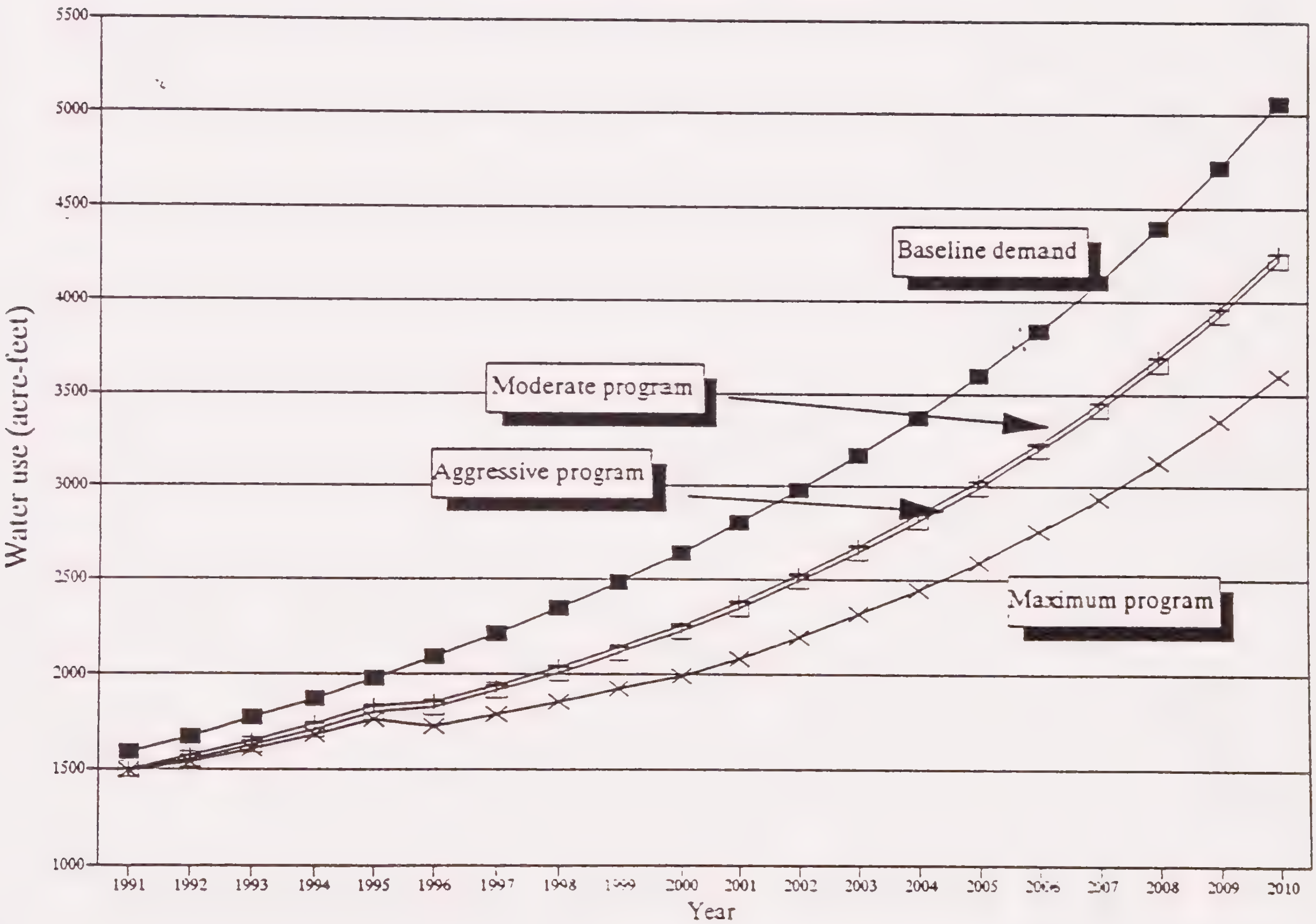
- Landscape ordinance for all new construction

- Assuming meters are in place, seasonal pricing of water and the use of an inverted (increasing) block rate structure

Figure ES-1 shows the estimated water savings resulting from the implementation of each program as compared to estimated baseline water use (without conservation). Baseline water use is the usage estimated assuming no conservation measures are in place. Water savings below baseline are approximately 16, 17, and 29 percent for the Moderate, Aggressive, and Maximum programs, respectively.

The economic feasibility of the programs depend on how their benefits are estimated. Basing the benefits strictly on the avoided cost of developing more groundwater indicates that conservation is not economical in the near term. However, assuming that groundwater will be limited in the future and that expensive surface water will need to

Figure ES-1
ESTIMATED WATER USAGE

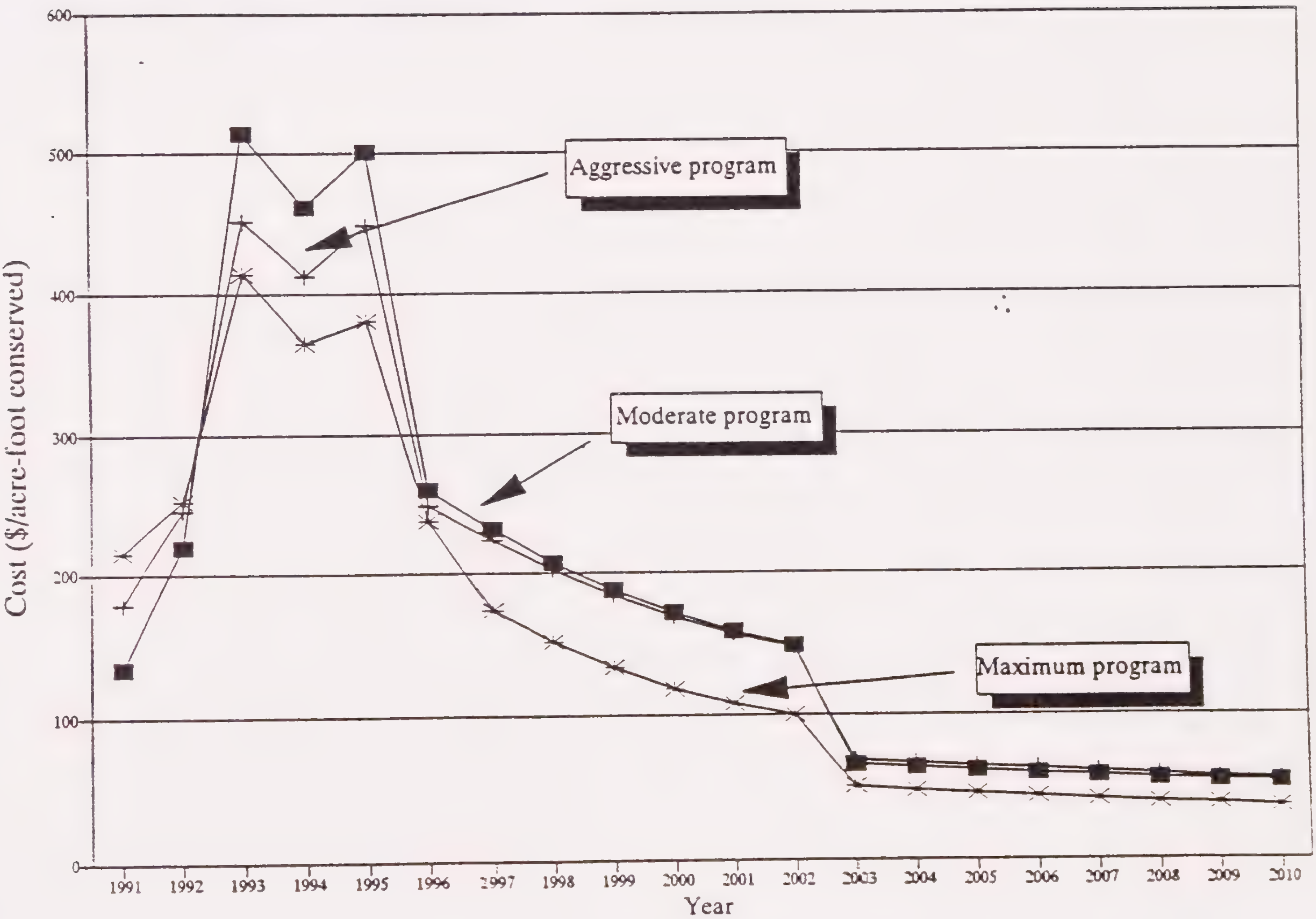


be imported into the Winters service area, significant economic benefits are attributable to the conservation programs. Implementing any of the three programs effectively augments the current groundwater supplies and delays capital costs associated with developing new water sources.

Figure ES-2 shows the cost of implementing the conservation programs on a per-acre-foot basis. Although all programs have high initial costs, the long-run costs are reduced to a level comparable to the current cost of groundwater pumping, and well below the cost of surface water development.

It is recommended that the City consider implementing the Moderate program as soon as possible. It is further recommended that water usage be carefully monitored over the next 5 years. At the end of this period, the City should re-evaluate the conservation program and implement the Aggressive or Maximum program, as necessary, to achieve its conservation goals.

Figure ES-2
CONSERVATION COSTS PER ACRE-FOOT



1. INTRODUCTION

An abundant supply of groundwater has yielded few incentives for the City of Winters to meter its water use and monitor water use trends. However, rapid development of this Coastal Range community and 5 consecutive years of drought are raising concern among City officials and citizens about the depletion rate of the underlying groundwater aquifer. Winters residents support the principles of water conservation and are willing to implement water conservation measures to prolong the life of the aquifer, or until other sources of water are developed. However, like other unmetered cities in the Central Valley, the residents have developed a fairly water-intensive lifestyle characterized by extensive landscape irrigation. The success of a long-term conservation program will probably depend on the ability to implement the program in a manner that minimizes sudden disruptions to residents' lifestyles. Alternatively stated, a long-term conservation program may have a better chance of local acceptance if phased-in over time rather than abruptly imposed.

2. WATER DEMAND

Measuring the impact of future water conservation depends on having a reference point from which to measure. This reference point, termed the baseline, is the level of water demand expected if no conservation measures are in place. Baseline levels of water use are developed in this section for each type of water use in Winters (residential, commercial, industrial, schools, and parks) for the period 1990 through 2010. These levels will be subsequently used in assessing water conservation measures.

Developing the baseline is hindered by a lack of Winters-specific data. However, by using the available Winters data and combining it with data from other nearby cities with similar population and demographics, a reasonable baseline can be developed.

CURRENT WATER USE

Existing well records indicate that Winters pumped about 487 million gallons of water, or about 1,500 acre-feet, between May 1989 and April 1990.[1] About 77 percent of this volume was used by the residential sector, 12 percent by schools, 5 percent by commercial interests, 4 percent by industrial users, and 2 percent for park maintenance (Figure 2-1). It is apparent from Figure 2-1 that the residential sector may be the most effective area in which to begin targeting water conservation.

It is of interest to note that inflows to the City's wastewater treatment plant are about 40 percent of the water pumped at the City's wells.[2] In the absence of major leaks in the system, this indicates that about 50 to 60 percent of total water use is outdoors.

RESIDENTIAL USE

Dividing total water production in Winters by the population results in a usage figure of 297, or 300 (rounded) gallons per capita per day (gpcd). Of this, about 230 gallons (77 percent) is used for residential purposes. This figure is consistent with the City of Davis' estimate of 233 gpcd for single-family residential housing,[3] but slightly higher than Woodland's overall residential estimate of 200 gpcd.[4] For purposes of this analysis, residential water use in Winters is assumed to be 230 gpcd, of which about one-third is used within the house and two-thirds is used outdoors (Figure 2-2).[5]

---

[1] CH2M HILL. *Water System Master Plan, City of Winters.* September 1990. The water production figure of 487 million gallons is based on 361 days. Water use estimates were accordingly adjusted.

[2] Personal communication with Robert Pexton, CH2M HILL, February 18, 1991.

[3] Personal communication with Jacques DuBrae, City of Davis, February 12, 1991.

[4] Personal communication with Lynn Chancellor, City of Woodland, February 12, 1991.

[5] U.S. Department of Housing and Urban Development (HUD). *Residential Water Conservation Projects Summary Report.* HUD-PDR-903. July 1984. The per capita indoor residential use estimate was about 77 gallons.

Figure 2-1
CATEGORICAL WATER DEMAND

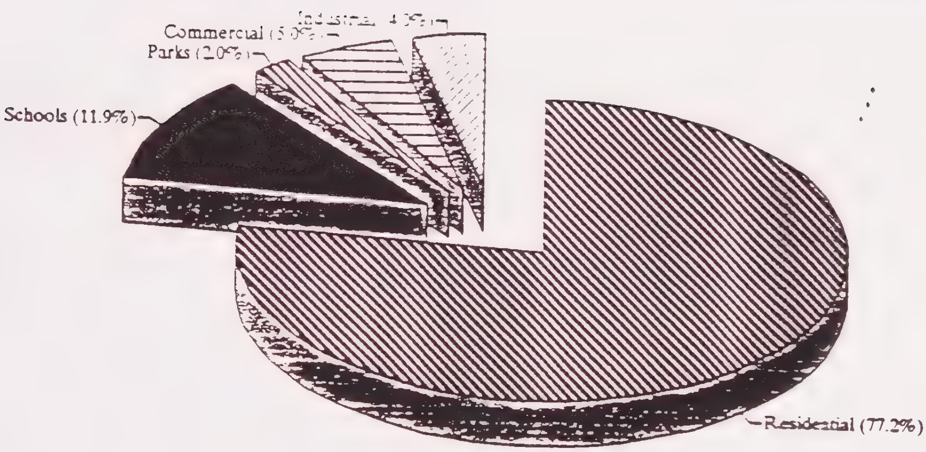
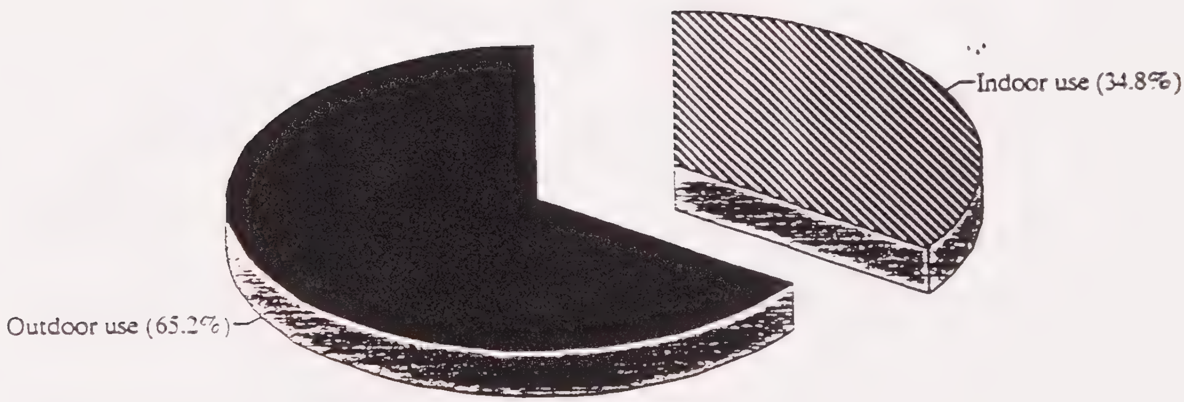


Figure 2-2
RESIDENTIAL INSIDE/OUTSIDE WATER USE



Of the residential water used for indoor purposes, toilet flushing uses 35 percent of the total indoor use; showers and bathing 18 and 10 percent, respectively; laundry 22 percent; drinking 13 percent; and dishwashing 2 percent (Figure 2-3). The remainder of residential water use is accounted for by outdoor purposes, mainly landscape irrigation.

PARKS, INDUSTRIAL, COMMERCIAL, AND SCHOOL USES

Nearly all water used for parks is for landscape irrigation. Industrial uses are mainly composed of two nut operations which use the water for processing rather than irrigating. Water for schools most likely has the same use characteristics as the residential sector. Commercial interests use water for both human consumption and washing.

None of the non-residential uses show potential for saving a large amount of water in terms of volume. However, these non-residential uses, particularly parks and schools, will be viewed as examples of water conservation by Winters residents. If neither the City nor School District make a strong commitment to water conservation regarding their own landscape irrigation, residents will have little incentive to follow suit.

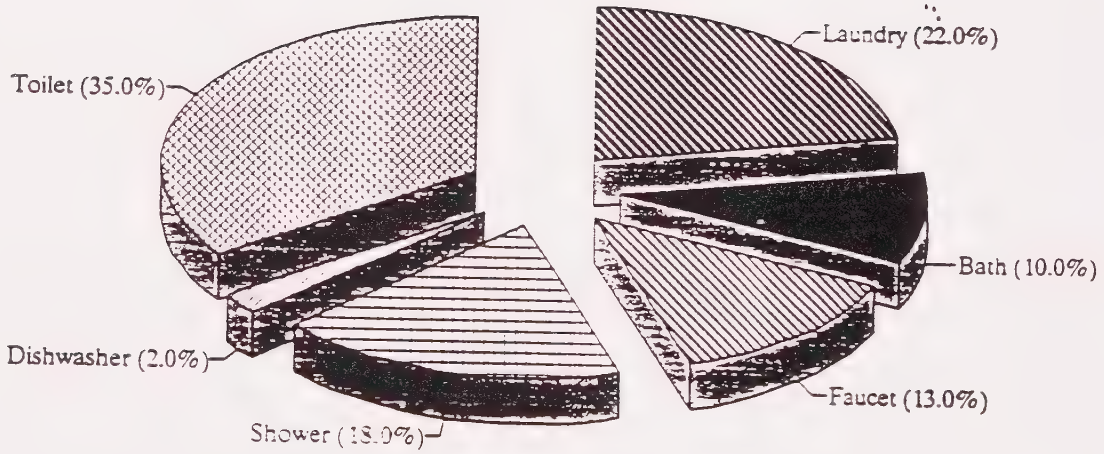
FUTURE WATER USE

Future water use in Winters is estimated based on anticipated patterns of land use. These patterns, identified in the General Plan, adopted in May 1992, describe the mix of residential housing, commercial businesses, industries, parks, and schools anticipated for the year 2010. The anticipated level of water demand for each demand sector is presented in Table 2-1.

Table 2-1
Winters' Annual Water Usage in 2010
(Estimated Population 12,500)

Type of Water Use	Volume Used
Residential (acre-feet)	3,550
Schools (acre-feet)	600
Parks/public areas (acre-feet)	360
Commercial (acre-feet)	320
Industrial (acre-feet)	350
Total (acre-feet)	5,180

Figure 2-3
RESIDENTIAL INTERIOR WATER USE



This analysis assumes that on a per capita basis, indoor water use for toilets and showers declines at a rate of 2 percent and 1 percent, per year through 2010. For all other uses, both indoor and outdoor, per capita use remains the same. Per capita, residential water use for indoor purposes falls from about 230 gpcd to 216 gpcd, summarized in Figure 2-4.

As shown in Table 2-1, the 1992 General Plan indicates that total water demand increases to approximately 5,180 acre-feet in 2010. Figure 2-5 summarizes demand over time for the various water uses.

Figure 2-4
PER CAPITA INDOOR WATER USE

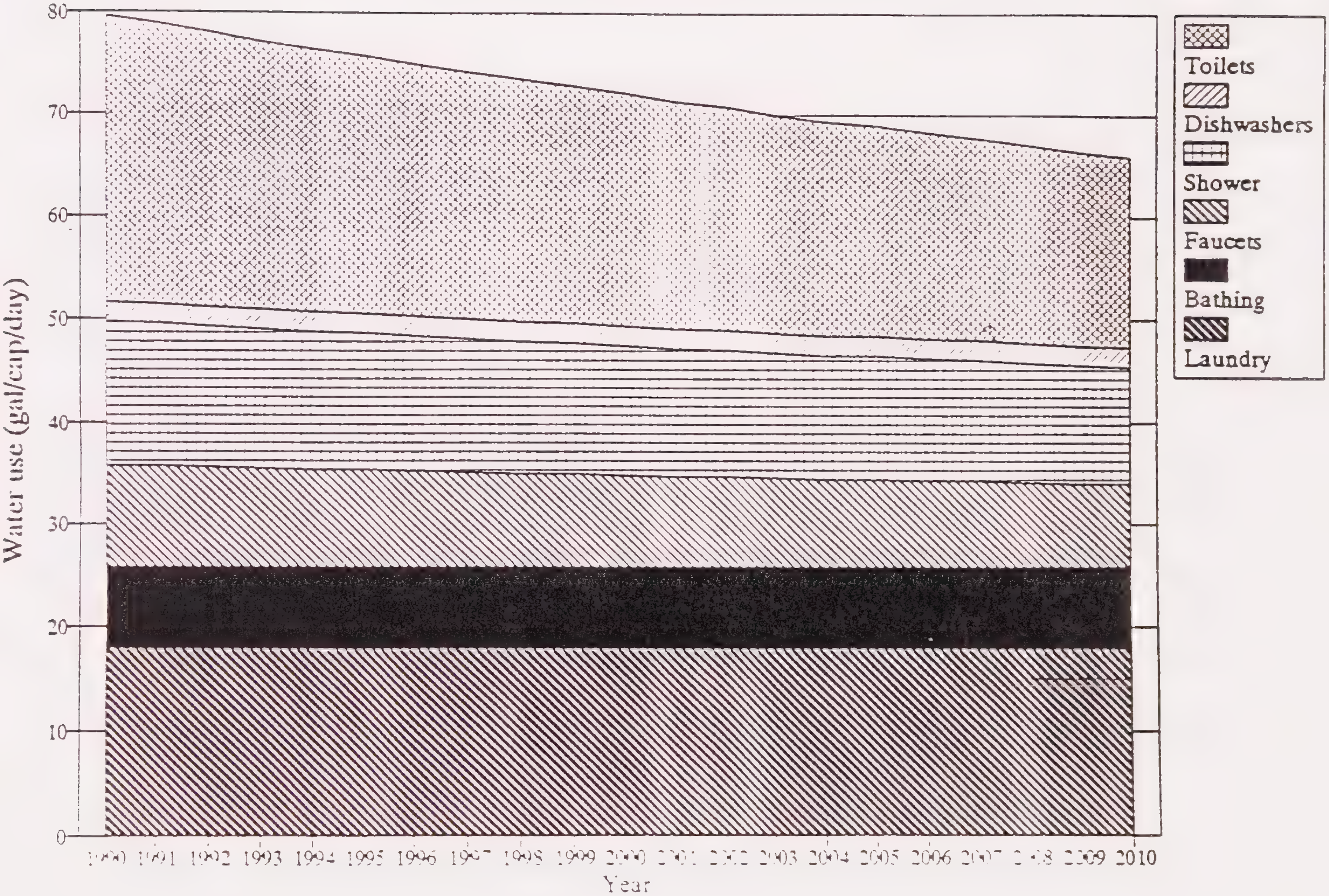
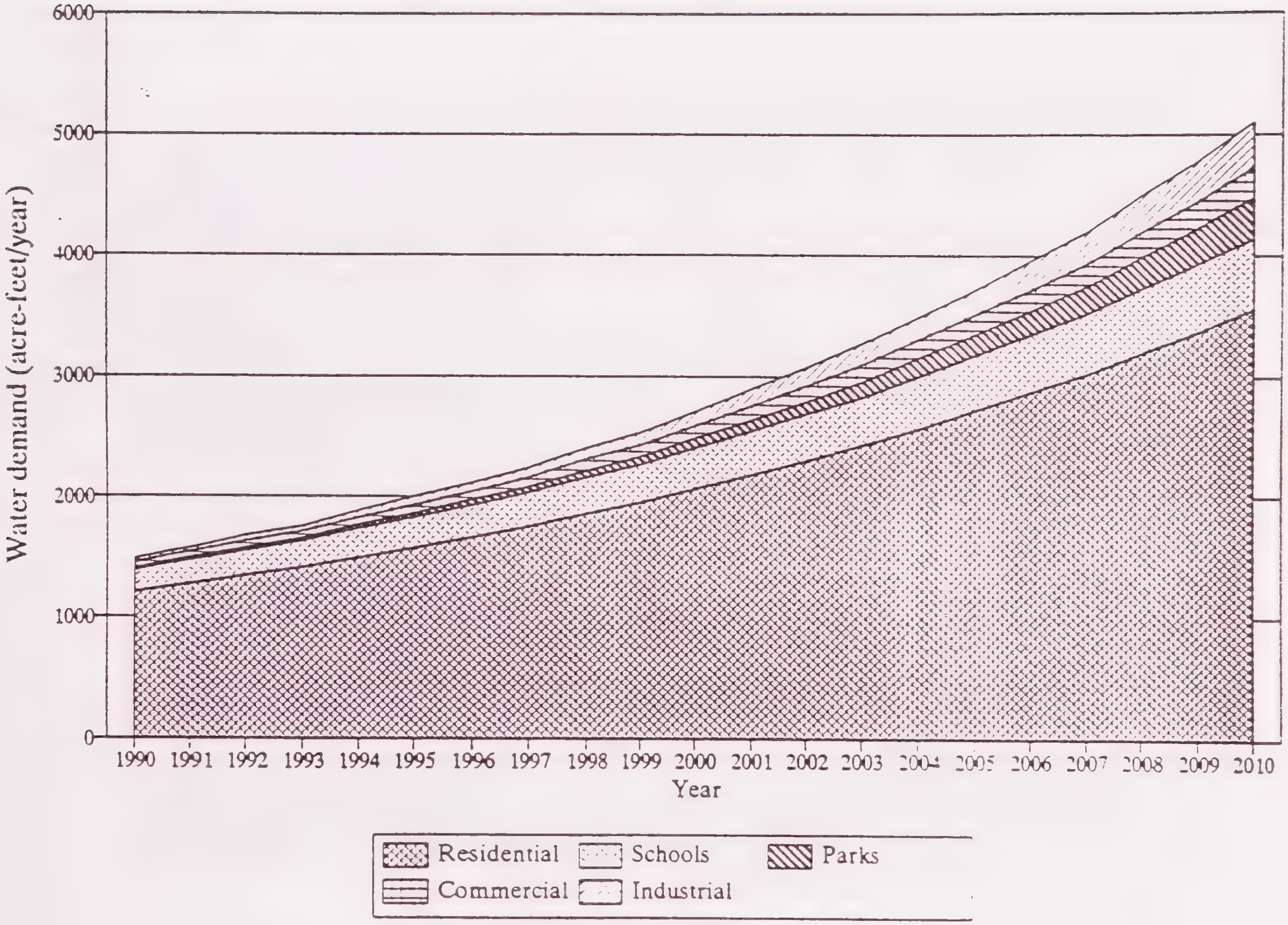


Figure 2-5
BASELINE WATER DEMAND: 1991-2010



3. WATER SUPPLY

The City water supply depends on groundwater supplied by five wells. Well 1 is currently out of operation. Portions of the Winters Water System Master Plan succinctly summarize the current water system:

> In 1989 the corresponding pumps were rated by Pacific Gas and Electric (PG&E) as operating with excellent efficiencies, ranging from 75 to 80 percent. The pumps vary in size from 60 hp to 100 hp, with well production at approximately 1,500 gpm each. PG&E conducts yearly pump and motor efficiency test on all wells. (p. 12)
>
> The ability of the system to deliver water during power outages is limited to the capacity of the elevated tanks. The 200,000-gallon storage capacity would last about 3 hours under average demand condition. The pumps are driven by electric motors and there are currently no sources of backup power. (p. 12)
>
> The distribution network is generally made up of 2- to 10-inch lines and one 12-inch main, which runs down Grant Avenue. Pipes range in age from 4 to 100 years old. (p. 12)

As described in the Water System Master Plan, Winters currently has a reliable, low cost supply of water. Since water treatment other than chlorination is not necessary, the low cost is passed directly on to the consumer. There are very few water meters in the City, although all new development will be equipped with meters. Metering will be discussed in more detail in the following section.

Aside from the vulnerability to a severe power outage, the City is examining ways to increase the long-term reliability of its water supply: conducting a groundwater study and investigating alternative sources of water.

GROUNDWATER STUDIES

CH2M HILL has recently completed a groundwater study to determine the remaining life of the underlying aquifer and gain insight to the area's safe annual yield. Safe annual yield refers to the volume of water that can be annually pumped without over-drafting the aquifer. Given the absence of detailed data and the inter-relationships of Putah Creek with the groundwater levels, safe annual yield could not be conclusively determined. The State Water Resources Control Board is currently conducting an overall adjudication of the Putah Creek Basin to allocate the basin's safe annual yield.

ALTERNATIVE SOURCES OF WATER SUPPLY

In addition to groundwater, three alternative water sources can be identified: surface water supplies, water/treated wastewater exchanges with surface water irrigators near Putah Creek, and reuse of treated wastewater.

SURFACE WATER SUPPLIES

Municipalities within both Yolo and Solano Counties are interested in obtaining surface water supplies. One of the more likely options for Winters is coordinating with nearby cities, such as Woodland and Davis, to obtain the supply and construct conveyance and treatment facilities. Like Winters, neither of these cities currently has the water treatment facilities necessary to use surface water. There is currently a proposal for a joint Woodland/Davis treatment facility southwest of Woodland. If Winters becomes a part of this consortium (taking advantage of economies of scale in water treatment), the water would still need to be conveyed from the treatment plant to the City system.

Several unanswered questions characterize this alternative, however. The main one involves the source of the additional supplies of surface water: whether they come from the unallocated portions of current surface water supplies; or whether they are transferred to municipal and industrial uses from existing uses such as agriculture. A second question regards the cost of acquiring the additional supplies.

An important advantage of developing this alternative is the access it provides to surface water purveyors. Although possibly accelerated by the current drought, there are indications that a new era of surface water allocation, and potential transfers, is beginning. There is a growing movement to use a market-oriented approach to allocate water in California. In this context, access to a larger "pool" of water may lead the way in gaining additional supplies through innovative transfers, such as lease-option agreements with agricultural users.

WATER/TREATED WASTEWATER EXCHANGES

A second alternative involves the City trading treated wastewater for irrigation water supplies originating in Lake Berryessa. The City would then have to treat the water or use it to recharge the groundwater aquifer through percolation. Financial incentives may be necessary to find a willing participant. Alternatively, treated wastewater may be exchanged with local irrigators to induce them to pump less groundwater. thereby leaving more groundwater available to the City.

Treating wastewater to a level suitable for direct human contact, such as for use in public parks and landscape irrigation, requires a 10/10 level of treatment.[6] Winters' Sewer Master Plan indicates that the cost of treating wastewater to this degree would be prohibitive in the context of its other water source alternatives.

---

[6]10/10 refers to the milligrams per liter (mg/l) concentration of total dissolved solids (TDS) and biochemical oxygen demand (BOD).

A 20/20 level of treatment, sufficient for irrigating golf courses, median strips, and non-food crops, is being considered for exchanges with local irrigators to reduce their groundwater pumping. The Sewer Master Plan estimates that a 1.5-million-gallon-per-day (mgd) expansion to the current wastewater treatment facilities, which would treat water to a 20/20 level, will cost approximately $10 million. Depending on the financial assumptions used, the effective cost of the reclaimed water ranges from $160 per acre-foot (using a 3 percent rate of discount) to $530 per acre-foot (using a 10 percent discount rate). Although it is uncertain how the cost of this reuse alternative compares with surface water importation, it appears that limited use of treated wastewater is economically competitive with Winters' alternative water sources.

REUSE OF TREATED WASTEWATER

This strategy is gaining popularity in water-short resort areas such as Tucson, Arizona; and Santa Barbara and Monterey, California. It involves using treated water for landscape irrigation. The feasibility of reuse depends on the cost of implementation. The water itself can be obtained at no cost, but there needs to be a dual water system specifically for the reused water. The aforementioned cities found reuse economical because there were large, open areas to irrigate, such as golf courses, large city parks, and roadway medians.

Treated wastewater could also be used to recharge the aquifer, although the water quality impacts have not been considered.

COST OF ALTERNATIVE WATER SUPPLIES

The cost to Winters associated with pumping additional groundwater is low. Assuming a 60-foot depth to water and reasonable assumptions regarding other variables, the marginal cost of pumping, on a per acre-foot basis, is about $20.[7] This only accounts for the energy cost of additional pumping and does not include capital costs of the well facility and operating costs.

If a new well is necessary to obtain additional supplies of groundwater, the cost increases significantly. Depending on the well's utilization and the frequency of its rehabilitation (among many other factors), its per-acre-foot cost can vary between $10 and $100.[8] Assuming a point at the lower end of the utilization range, say 35 percent (resulting in a cost of $30 per acre-foot), the overall total cost of continuing to develop the groundwater source is approximately $50 per acre-foot.

---

[7] System pressure at the pump is assumed to be 45 pounds per square inch (psi); the well pump is assumed to be 75-80 percent efficient; actual PG&E power rates of $.095 per kilowatt (kWh) are used.

[8] This assumes that total costs for a 1,500-gpm well are $245,000, the discount rate is 10 percent, and its useful life is 50 years. It is further assumes the well's utilization can vary from 100 percent ($10 per acre-foot) to 10 percent ($100 per acre-foot).

The cost of the surface water alternative is uncertain and has not been estimated for Winters. But Borcalli and Associates have made similar estimates for the City of Woodland.[9] Although there would still be additional costs to Winters in terms of additional conveyance, the Woodland figures are useful as order-of-magnitude estimates. Amortizing Borcalli's estimates over a 30-year time period at a 10 percent discount rate results in a per-acre-foot cost of $200. This covers conveyance and treatment costs only; acquisition costs were not considered.

Borcalli also looked at a Davis and Woodland joint venture and at Woodland obtaining additional surface supplies from the Sacramento River. This resulted in a cost of $185 per acre-foot. Again, this does not consider water acquisition costs.

Overall, continued development of groundwater is significantly less expensive than developing alternative surface water sources. However, this is not an endorsement of additional groundwater pumping. There are other factors Winters must consider beyond the short-term cost differences, primarily the continued availability of groundwater both in absolute terms and in terms of the interaction of the local groundwater basin with Putah Creek.

As a point of interest, the surface water cost estimates presented above, although specific to Woodland, are comparable to the costs of additional water in many other parts of California. Desalination, an expensive option being investigated in many large coastal water purveyors, costs more than $1,500 per acre-foot to develop. Metropolitan Water District of Southern California (MWD) anticipates development cost for new sources of water to be well in excess of $200 per acre-foot. Other Central Valley cities currently using significant amounts of groundwater, such as Merced, Fresno, and Sacramento, will also pay more than $200 per acre-foot to develop surface water supplies.

---

[9] Borcalli and Associates, *Supplemental Surface Water Supply Development Program.* Prepared for the City of Woodland, Public Works Department. June 1990.

4. WATER CONSERVATION ALTERNATIVES

Because of the adequate supply of underlying groundwater, Winters has never experienced a water supply shortage. Consequently, it does not have an explicit water conservation plan or policy. However, given the rapid rate of growth anticipated for the area, the City's dependence on a single source of water, and the duration of the current drought conditions, there is a heightened awareness of the role of water conservation both as a source of water and a demonstration of good water stewardship.

A water conservation program consists of one or more individual conservation measures. This section identifies three alternative programs and discusses the specific conservation measures within each.

POTENTIAL WATER CONSERVATION PROGRAMS

The three alternative water conservation programs include a Moderate program, which attempts to minimize out-of-pocket expenses of conservation to the City and existing residents; an Aggressive program, which builds upon the Moderate program by including additional measures; and the Maximum program, which adds water pricing incentives and a landscape ordinance to the previous programs. Each successive program conserves more water than the previous one.

The City may want to consider a phasing-in approach to program implementation. This would involve immediately implementing the Moderate program and observing the resulting water savings over several years. If the savings are considered adequate, in the context of maintaining water use below the groundwater aquifer's safe annual yield, then the program remains in place. If the savings are inadequate, or population grows faster than anticipated, a more stringent program will be implemented.

THE MODERATE PROGRAM

This program consists of five measures. Portions of at least one of the measures will be required by State law after January 1, 1992, and a second will most likely be implemented by the City regardless of whether an Urban Water Management Plan is implemented. The measures include:

- Low-flow plumbing ordinance on new construction
- Retrofit of low-flow plumbing fixtures as older fixtures wear out
- Alternate-day, odd/even outdoor watering schedule
- Public education and a "water waster" ordinance
- Metering of new construction
- Meter retrofit of existing structures in conjunction with main replacement

Portions of the first two measures, requiring ultra-low-flow toilets, will be state-mandated as of January 1, 1992. Metering of new construction has already been planned by the City and will most likely be in effect in the near future. As a result, the new measures proposed by the Moderate program are the alternate-day watering, public education, and the retrofit of meters in conjunction with the main replacement program.

THE AGGRESSIVE PROGRAM

The Aggressive program consists of the Moderate program plus four additional measures:

- Plumbing retrofit and water audits of selected residential housing and businesses
- Landscape ordinance for multi-family housing and businesses
- Additional public educational measures and a "bounty" program for reporting water wasters

THE MAXIMUM PROGRAM

This program builds upon the previous two by adding the following measures:

- Landscape ordinance for all new construction
- Assuming meters are in place, seasonal pricing of water and the use of an inverted block rate structure

To an extent, the Maximum measures are not complementary with one another. For instance, with an inverted rate structure, customers should be able to landscape their property as they please, as long as they are willing to pay for the water. However, many perceive that water conservation through pricing strategies is regressive against the less affluent because it may result in only the more affluent having green lawns. Therefore, a landscape ordinance provides a measure of equity between social classes.

WATER CONSERVATION MEASURES

Estimates of water savings and costs associated with each conservation measure are discussed below. It is important to note that these estimates are somewhat uncertain due to both a lack of reliable data regarding water conservation measures in smaller cities, and the uncertainty of how individual measures perform when combined with other measures into a larger program. An example of the latter problem might be the case for water meters. In general, a conservation measure will show greater savings when imposed in isolation rather than in combination with other measures. Therefore it is important to concentrate more on the performance of the overall program than single measures.

LOW-FLOW PLUMBING ORDINANCE FOR NEW CONSTRUCTION

A low-flow plumbing ordinance for new construction can take many forms. Davis' 1990 Urban Water Management Plan,[9] for instance, recommends a plumbing code that includes the mandatory ultra-low-flow, 1.6-gallon-per-flush toilet, 2.0-gallon-per-minute (gpm) showerheads and faucet aerators, water-conserving models of appliances (specifically dishwashers and clothes washers), and insulation of hot water pipes. The resulting cost of implementing this measure was estimated to be approximately $33,000 annually. The water savings was estimated to be approximately 0.67 mgd or about 17 gpcd.

A scaled-back version of Davis' ordinance is suggested for the Moderate program. It includes requirements for ultra-low-flow toilets, 2.5-gpm faucets and showers, and recommendations for water-conserving appliances, and is estimated to conserve about 13 gpcd. The differences between the two ordinances include more liberal faucet flows and only recommendations for water-conserving appliances rather than mandatory requirements. The rationale behind this less stringent recommendation is based on the recent state law requiring 1.6-gallon toilets and the observation that popular models of plumbing fixtures and water using appliances require less water than their predecessors. Since the California plumbing industry is already moving in a water conservation direction, there is little incentive to implement a more severe ordinance.. The question then arises as to why Winters should consider this type of ordinance at all. This analysis estimates that for zero "out-of-pocket" expense, and an estimated $500 to $1,000 per year in implicit administrative costs, the City can both conserve water and demonstrate to the rest of the state that it is committed to water conservation.

It is notable that newer models of 1.6-gallon toilets perform significantly better than previous ultra-low-flow models. However, this performance improvement results in a significantly more expensive toilet. Therefore, the ordinance will result in increased costs to customers, but no more additional costs than would be incurred if the City did nothing, by virtue of the state requirements. Additional cost to customers, then, is assumed to be zero. Many municipalities in the west offer customer rebates for the purchase of 1.6-gallon toilets. Denver, for instance, will rebate $80 per toilet.

LOW-FLOW PLUMBING ORDINANCE FOR RETROFITTING EXISTING STRUCTURES

This requirement can be either tied to the new housing ordinance or passed as separate legislation. It would require that as old plumbing fixtures wear out, they are replaced with water-conserving fixtures, including the 1.6-gallon toilet and 2.5-gpm faucets and shower aerators. Nothing about this measure is currently included in existing state legislation. As applied to Winters, however, this measure could be rather passive because there are no provisions for mandatory retrofit or in-house inspections. As a result, there is the possibility that some households will not comply, preferring to use

---

[9] Brown and Caldwell. *City of Davis Urban Water Management Plan.* January 1990.

the less expensive 3.5-gallon toilets. This analysis assumes that households replace toilets only once every 30 years, and showerheads and faucet aerators every 10 years. About 60 percent of those households replacing toilets are assumed to comply with the ordinance.

Water savings resulting from this measure is estimated to be about 10 gpcd for complying customers. Depending on how the ordinance is structured in relation to the new housing ordinance, implementation costs are estimated to be about $500 annually.

ALTERNATE-DAY LAWN WATERING

Alternate-day lawn watering, a common restriction in western states, has been applied in California extensively in recent years in response to drought conditions. Specifically, this measure limits watering of lawns on those properties with odd-numbered addresses to odd-numbered calendar days, and vice-versa for even-numbered addresses. In addition, no outdoor watering is allowed on Mondays and there is no watering for anyone between 10 a.m. and 6 p.m. during June through September. This measure proposes to make these restrictions permanent rather than simply during the current drought.

Although some resistance to this measure is expected, there is no evidence of landscape damage or lifestyle changes occurring in any of the cities that have implemented this program. There may be a slight inconvenience to households with mechanical timers on their automatic sprinklers that cannot recognize specific days of the week. However, this inconvenience is thought to be minimal. Some exceptions should be built into the water restrictions, however, such as allowing daily watering of newly planted yards and newly laid sod.

Sacramento realized about a 15 percent water savings resulting from this type of restriction in 1990, although some of this savings may also be due to a heightened awareness of water conservation. Per-capita water use decreased about 40 to 50 gallons per day. A more conservative estimate of savings of 30 gpcd is assumed in this analysis. The cost to the City results from enforcement, estimated to be about $1,000 annually.[10]

PUBLIC EDUCATIONAL PROGRAMS

Public education is critical to the success of any water conservation program. Customers need to be aware of not only their current water use and the volume of City water supplies, but also how conservation can help the City, and themselves, save money over the long term. Customers may need to be convinced there are economic and social incentives to conserve rather than conserving for the sake of conservation itself. Obviously, this is much easier to accomplish during a drought or during other periods of limited water supplies.

---

[10]This figure is somewhat arbitrary since a host of factors may influence the cost of implementation. These might include City staff availability and the level of enforcement the City desires.

Like plumbing ordinances, educational programs can take many forms. Possibilities include radio advertisements (although Winters does not have a radio station), newspaper ads, guest speakers for schools, posters, bill stuffers (Winters' bills are in the form of a postcard), and booths at local fairs. Measures targeting outdoor water use might include landscape irrigation guides, evapotranspiration (ET) information printed daily in the local newspaper, xeriscape promotion, and landscape demonstration plots in parks.

Part of the success of an educational program is the targeting of specific water user groups and directing portions of the program at them. For instance, the City may want to target new residents. This might be accomplished by supplying them literature when they open a water service account with the City. For existing residents, distributing literature and setting up displays at the local grocery stores and businesses may be the most effective.

In conjunction with the education measures, it is recommended that the City implement a "water waster" ordinance. Also known as "gutter flooding" ordinances, this allows the City to cite residents and businesses conspicuously wasting water. The first and second occurrence of water wasting should result in warnings. After this, however, it is recommended that fines be levied, increasing with the number of times an individual is cited.

This analysis does not identify or recommend specific educational measures for Winters beyond stating that, in general, a public education program is necessary to implement a successful water conservation program. It is estimated that water savings attributable solely to education is low, about 0.5 gpcd over the entire system. and the cost is roughly estimated to be about $3,000 annually.

It is possible that Winters could be a beneficiary of other cities' educational programs. Television, radio, and newspapers in the area are generally based in the Sacramento area. As a result, Winters may receive "free-rider" benefits from the programs of Sacramento, Woodland, and Davis.

METERING OF NEW CONSTRUCTION

With statewide pressures to meter water users, Sacramento residents have been stating "meters don't save water, people do." They are correct in the sense that a meter does not create more water. It can, however, change the pattern of water use in a community, and in many cases make more water available to the City. Meters have several benefits, including better accounting of water use (which may aid in detecting leaks in the system), the ability to base billing on actual water use, the ability to impose seasonal and peak period rates, and allowing alternative rate structures to aid in achieving water conservation goals.

Little resistance is expected from metering new construction because most of the potential Winters residents probably come from areas with meters. Given the level of growth anticipated in the City, at the end of the 20-year planning period, almost two-thirds of the City will be equipped with meters if this measure is adopted. Additionally,

metering new housing is relatively inexpensive compared to retrofitting meters on present structures. The main expense is the meter itself, assumed to be between $100 and $150 per meter. An additional, one-time cost of $10,000 is assumed for the metering measure to pay for a study needed to set water rates.

The City may want to examine including the cost of water meters for new construction into hook-up or development fees it currently imposes.

Water savings resulting from meters is estimated to be approximately 15 gpcd below the baseline level assumed for new structures. This mostly results from more careful outdoor watering.

METER RETROFIT OF EXISTING STRUCTURES

The City's Water Master Plan includes a 10-year water main replacement program. The meters will be retrofit as mains are replaced. It is estimated that the water savings for retrofit meters is the same as for the metering of new construction, about 15 gpcd. Although the cost of meter retrofit will tend to be low when tied to the main replacement program, there are additional costs above the costs of the meter itself. These additional costs are related to the age of the service lines connecting the main and the structures. These lines could be quite old and brittle, and may require some "patchwork." Overall, the analysis assumes approximately $250 per meter retrofit.

An issue not addressed with either metering measure is the timing of meter reading. It may not be economical to read meters in the near term, since there may not be enough meters to make reading them worthwhile. This analysis assumes that meters will begin to be read halfway through the 10-year replacement program, probably in 1996.

PLUMBING RETROFIT AND AUDIT OF SELECTED CUSTOMERS

A water audit is similar to an educational program. It benefits both the party being audited and, in the case of residential users, their neighbors and friends. This measure consists of the City either hiring or training a part-time water auditor and advertising for volunteer residential customers or businesses to be audited. The auditor will perform an indoor and outdoor water audit of the house or business and, in the process, retrofit the toilet(s) with a toilet dam and check for leaks, retrofit 2.5-gpm aerators on the faucets, and install a low flow showerhead(s). The auditor will also inspect the landscaping, demonstrate how to measure sprinkler water application rates, and leave literature regarding at-home water conservation.

Water savings resulting from the audit is expected to be 10 gpcd per resident audited. Because the program participation rate and the City budget are uncertain, it is recommended that the City fund the program at the rate of $6,000 annually for 5 years. This funding level is obviously not enough to support a part-time City employee, but is sufficient to test the residents' interest in the program. The program can be re-evaluated annually and funded accordingly. Winters may want to explore using retirees to perform the audits, or investigate a partnership with one of the larger near-by cities.

LANDSCAPE ORDINANCE FOR NEW COMMERCIAL AND MULTI-FAMILY CONSTRUCTION

Although possibly not applicable to Winters, the water departments of larger western cities have observed that due to a lack of accountability by commercial business employees and apartment dwellers, a significant amount of water is wasted when irrigating landscape.

A landscape ordinance for these types of construction is estimated to save about 5 gpcd over the entire water system. A model landscape ordinance developed by the state has, as its first step, the development of a water budget. The budget is based on the water requirements of a bluegrass-type turf and the area of landscape. The amount of water needed to maintain this turf is then multiplied by 0.80, which then becomes the upper limit to landscape water consumption. Additionally, the required landscape plan must be approved by a certified landscape architect or consultant.

The cost of implementing such a measure is uncertain, consisting of additional workload for City staff reviewing landscape plans. This analysis assumes an annual cost of approximately $1,000.

ADDITIONAL PUBLIC EDUCATION AND A "BOUNTY" PROGRAM FOR REPORTING WATER WASTERS

This measure simply expands the previous public education measure and institutes a system that encourages the reporting of water wasters. The "bounty" program might consist of a dedicated, confidential phone line where citizens can report violators. This measure is estimated to be more effective in terms of water savings (about 3 gpcd over the entire system) because it is anticipated that most of the additional funds ($3,000 per year) will be used for enforcement.

LANDSCAPE MEASURE FOR ALL NEW CONSTRUCTION

This extends the commercial and multi-family ordinance to all new construction, including all residential housing. The additional savings resulting from this measure is estimated to be 30 gpcd over the expected, baseline consumption level for the new residents. The additional administrative costs are estimated to be $3,000 annually.

SEASONAL PRICING OF WATER AND AN INVERTED BLOCK WATER RATE STRUCTURE

This measure assumes the presence of water meters. It involves achieving conservation through the pricing of water, e.g., raising the price of water during the hotter summer months to discourage waste. In addition, an inverted block rate structure could be considered. A block rate structure means that for the first increments of water used, 1,000 cubic feet for instance, the price is set at a certain level. The next 1,000 cubic feet of water passing through the meter may have a different price. With an increasing or "inverted block" rate structure, this second 1,000-cubic-foot increment is more expensive than the first; a third block (if defined) would subsequently be more expensive than the first, and so on. This is similar to the way PG&E prices electricity.

If implementing this measure, the City may want to consider establishing a "lifeline" rate for water, also similar to electrical utilities. This would make a minimum amount of water affordable for low income customers.

SUMMARY

Tables 4-1 through 4-3 summarize the programs in terms of estimated water savings and costs of implementation.

Table 4-1
Summary of the Moderate Program's Water Conservation Measures — Sheet 1 of 2

Measure	Low-flow plumbing ordinance for new construction	Low-flow plumbing ordinance for retrofitting existing structures	Alternate-day, odd/even, lawn watering
Description	As per state code (effective 1/1/92), requires all new construction use 1.6-gal toilets, 2.5-gpm showers and faucets, and water-conserving appliances.	Requires that low-flow plumbing fixtures be used when replacing current fixtures—1.6-gal toilet, 2.5-gpm showers and faucets, and water-conserving appliances.	Allows turf irrigation only on alternate days; houses with even-numbered addresses can only water on even-numbered days, and vice-versa; no watering on Mondays; no watering between 10 a.m. and 6 p.m. during June-Sept.
Estimated water savings over planning horizon	Saves 10-15 gpcd throughout the system. All of savings occurs indoors.	Assumed to save about 10 gpcd throughout the system. All of savings occurs indoors.	Overall system savings estimated to be approx. 30 gpcd. All savings occurs outdoors.
Program implementation	Can either be passed immediately by the City or wait until State law becomes effective.	Can be passed immediately by the City and wait until required by state.	Can be passed immediately. Allow exceptions for newly seeded and sodded lawns.
Budget requirements	None for City; will require customers to pay additional costs over the older 3.5-gal toilets. However, they will have to pay this regardless of the City actions.	None for City; will require customers to pay additional costs over the older 3.5-gal toilets. However, they will probably have to pay this regardless of the City actions.	None for the ordinance itself, but may require expenditures for enforcement. This analysis assumes $1,000 per year for enforcement.
Environmental, health, and safety considerations	None	None	None
Customer acceptance	Customers need to be convinced that newer technologies of toilets and showerheads work as well as older models.	Customers need to be convinced that newer technologies of toilets and showerheads work as well as older models.	Potential resistance from existing residents. May require some alterations to automatic sprinkler timers. No evidence to suggest that landscape damages will result. Many cities in the west have been using this system for years without changing landscaping or lifestyles.
Indirect benefits	Less inflow to City water treatment plant; less energy used for hot water heating.	Less inflow to City water treatment plant; less energy used for hot water heating.	None

Table 4-1
Summary of the Moderate Program's Water Conservation Measures — Sheet 2 of 2

Measure	Metering new construction	Meter retrofit when water mains are replaced	Public education and a "water waster" ordinance
Description	Install water meters on all new construction	Install water meters on existing structures when the nearest water main is replaced.	Initiate a public education program. It may include posters, ads in the local paper, grade school curriculum, or guest speakers. The "water waster" ordinance targets gutter flooding and conspicuous waste.
Estimated water savings over planning horizon	Estimated to save approximately 15 gpcd for new structures under a conservative pricing structure	Estimated to save approximately 15 gpcd when installed on existing structures.	Estimated to save only .5 gpcd, but complements other measures. It will improve the success of overall program.
Program implementation	Can be passed immediately. Requires that new construction immediately install water meters.	Can be implemented immediately. Requires retrofit as mains are replaced.	Can be passed immediately. Will likely need to be well thought-out in terms of targeting types of customers.
Budget requirements	City expenditures estimated to be approx. $150 per meter; can range from $100 to $350 per meter. This cost may be passed on to developer.	City expenditure estimated to be approximately $250 per meter; this can vary from $100 to $600 per meter depending on the type. This cost will ultimately be passed on to customers.	City expenditure is estimated to be about $3,000 per year. This can vary widely, however.
Environmental, health, and safety considerations	None	None	None
Customer acceptance	Minimal resistance expected from new customers - they most likely came from areas with meters.	Probable resistance from existing customers; may be perceived as an attempt to change customers' lifestyle.	No anticipated resistance.
Indirect benefits	Better accounting of water use.	Better accounting of water use; could potentially reduce water bills for customers already conserving; easier to detect leaks in system. If water rates are relatively high, less affluent customers could be hurt relatively more than the more affluent.	None

Table 4-2 Summary of the Aggressive Program's Water Conservation Measures			
Measure	**Plumbing retrofit and water audit of selected households and businesses**	**Landscape ordinance for new multi-family housing and businesses**	**Additional public education and a "bounty" program for reporting water wasters**
Description	The City would offer to perform a water audit for volunteer customers. As part of the audit, the City would provide and install plumbing retrofit devices.	This would require that proposed multi-family housing and commercial structures submit a landscape plan when applying for a building permit. The plan would generally limit landscape watering to about 75-80% of normal turf watering requirements.	Additional public education would supplement the Moderate program's efforts; the "bounty" program would encourage the reporting of violators of the water waster ordinance.
Estimated water savings over planning horizon	Estimated to be about 10 gpcd for the participating customer.	Systemwide savings are estimated to be about 5 gpcd.	Systemwide savings are estimated to be about 3 gpcd.
Program implementation	Can be implemented immediately. It is anticipated to be a 5-year program, 1992-1996.	Can be implemented immediately.	Can be implemented immediately.
Budget requirements	City expenditures are estimated to be $6,000 annually, which includes high quality retrofit kits and the services of a water auditor.	City expenditures for plan checking are estimated to be about $1,000 annually. It is not expected that new customers will have any additional expenditures above normal landscaping expenses.	City expenditures are estimated to be $3,000 annually.
Environmental, health, and safety considerations	None	None	None
Customer acceptance	No anticipated resistance since it is voluntary. Participants get a free plumbing retrofit.	No anticipated resistance.	No anticipated resistance.
Indirect benefits	Like other measures, it should reduce inflow to the wastewater treatment plant.	If cooperation is good and the landscaping plan is carried out properly, this could serve as an example to single-family residential builders and home buyers.	None specified

Table 4-3 Summary of the Maximum Program's Water Conservation Measures		
Measure	**Landscape ordinance for all new construction**	**Seasonal pricing of water and an inverted block rate structure**
Description	Requires a water-conserving landscape plan for the City's review when the building permit is issued.	Assuming meters are present, the pricing strategies will provide water-saving incentives.
Estimated water savings over planning horizon	For new structures, water savings is estimated to be 30 gpcd.	Savings is estimated to be approximately 40 gpcd.
Program implementation	Can be implemented immediately after an ordinance is drafted.	Can be implemented after a sufficient number of meters are installed.
Budget requirements	The analysis assumes the City will need approximately $5,000 annually for review and inspection.	The first year of implementation is assumed to require about $15,000 for a water rate study. Succeeding years are assumed to require $2,000 annually for additional billing processing.
Environmental, health, and safety considerations	None	None
Customer acceptance	No resistance expected	Potential for resistance depending on the level of rates. This measure may be perceived as regressive since it could favor the more affluent households.
Indirect benefits	May delay additions to wastewater treatment facility.	Probable reduction in wastewater inflows to treatment plant; may allow for delaying its expansion.

5. EVALUATION OF THE WATER CONSERVATION PROGRAMS

This section evaluates the water savings and economic benefits and costs resulting from the conservation programs. All economic estimates are presented in 1991 dollars, assuming zero inflation over the next 20 years. Although inflation will certainly occur over the 20-year planning horizon, conducting the analysis in 1991 dollars facilitates comparison of the conservation alternatives.

Appendixes A, B, and C contain printed computer spreadsheets used to evaluate the individual measures composing the three conservation programs. The tables shown in this section are summaries of data contained in the appendixes.

MODERATE PROGRAM EVALUATION

Table 5-1 summarizes the estimated water savings resulting from implementing the Moderate water conservation program. As mentioned in Chapter 2, these results are based on a 2010 population of 12,500. The summary is presented in terms of both acre-feet and gpcd saved for each conservation measure, on a citywide basis. It is important to view the water savings attributable to individual conservation measures with caution because there are interrelated impacts among the various measures implemented. Alternatively stated, an individual measure will appear to be more effective when implemented in isolation rather than in conjunction with other measures.

The overall water savings resulting from the Moderate program is estimated to be 91 acre-feet in 1991, increasing to 830 acre-feet in 2010. Slightly less than one-half of the 2010 savings, 400 acre-feet, is credited to the alternate-day lawn watering restrictions. More than one-third, 274 acre-feet, is credited to metering. The remainder is attributable to the plumbing ordinances (150 acre-feet) and public education (7 acre-feet). The Moderate program reduces citywide water demand by about 16 percent from the estimated baseline level.

Table 5-2 summarizes the program's water savings in terms of indoor versus outdoor savings, and its economic characteristics. As expected, most of the water conservation is realized outside the home. Dividing the total program cost by the volume of water conserved results in an estimate of the cost per acre-foot conserved. As shown in Table 5-2, the 1991 program cost is estimated to be $135 per acre-foot conserved. This increases to $219 per acre-foot in 1992 as the metering program begins, and then jumps to $500 for the year 1995 when a water rate study is recommended to be conducted. The per-acre-foot conservation costs then decline steadily over time, to $53 in 2010.

Table 5-1
Citywide Water Savings Through Conservation: Moderate Program

Year	Plumbing Ordinance: New Construction		Plumbing Ordinance: Retrofit		Alternate-Day Watering		Public Education		Metering: New Construction		Metering: Retrofit		Total Savings		Percent Savings
	(acre-feet)	(gpcd)	(acre-feet)	(gpcd)	(acre-feet)	(gpcd)	(acre-feet)	(gpcd)	(acre-feet)	(gpcd)	(acre-feet)	(gpcd)	(acre-feet)	(gpcd)	
1991	3	0.6	2	0.3	82	15.0	3	0.5	0	0.0	0	0	90	16	5.6
1992	7	1.2	3	0.6	90	15.6	3	0.5	0	0.0	0	0	103	18	6.1
1993	11	1.8	5	0.9	98	16.2	3	0.5	0	0.0	0	0	117	19	6.6
1994	15	2.3	7	1.1	107	16.8	3	0.5	0	0.0	0	0	131	21	7.0
1995	19	2.9	9	1.3	116	17.4	3	0.5	0	0.0	0	0	147	22	7.4
1996	23	3.3	10	1.5	126	18.0	4	0.5	35	4.9	41	6	239	34	11.4
1997	28	3.8	12	1.6	137	18.6	4	0.5	43	5.8	49	7	272	37	12.3
1998	33	4.3	14	1.8	148	19.2	4	0.5	51	6.6	57	7	307	40	13.1
1999	38	4.7	16	1.9	161	19.8	4	0.5	60	7.4	66	8	344	42	13.8
2000	43	5.1	17	2.0	174	20.4	4	0.5	69	8.1	74	9	382	45	14.5
2001	49	5.5	19	2.1	188	21.0	4	0.5	79	8.8	82	9	422	47	15.0
2002	55	5.8	21	2.2	204	21.6	5	0.5	89	9.5	82	9	455	48	15.3
2003	61	6.2	23	2.3	220	22.2	5	0.5	100	10.1	82	8	490	50	15.5
2004	68	6.5	24	2.3	237	22.8	5	0.5	111	10.7	82	8	528	51	15.6
2005	75	6.8	26	2.4	256	23.4	5	0.5	123	11.3	82	7	567	52	15.8
2006	82	7.1	28	2.4	276	24.0	6	0.5	136	11.8	82	7	609	53	15.8
2007	89	7.4	29	2.4	297	24.6	6	0.5	149	12.3	82	7	653	54	15.9
2008	97	7.7	31	2.5	320	25.2	6	0.5	163	12.8	82	6	699	55	15.9
2009	106	7.9	33	2.5	344	25.8	7	0.5	177	13.3	82	6	748	56	15.9
2010	115	8.2	35	2.5	370	26.4	7	0.5	192	13.7	82	6	800	57	15.8

Table 5-2
Economic Evaluation of the Moderate Conservation Program

Year	Total Savings (acre-feet)			Program Costs ($)			Cost per Acre-Foot Conserved ($)	Benefit of Program ($), Based on Avoided Cost of	
	Indoor Uses	Outdoor Uses	Total	City Outlays	Customer Costs	Total		Groundwater	Surface Water
1991	7	83	90	4,750	7,345	12,095	135	4,493	16,624
1992	12	91	103	15,250	7,345	22,595	219	5,147	19,046
1993	18	99	117	52,620	7,345	59,965	513	5,840	21,606
1994	23	108	131	53,305	7,345	60,650	461	6,572	24,315
1995	29	118	147	66,140	7,345	73,486	500	7,346	27,180
1996	60	178	239	54,802	7,345	62,147	260	11,943	44,188
1997	72	200	272	55,621	7,345	62,966	231	13,620	50,394
1998	84	223	307	56,489	7,345	63,834	208	15,369	56,864
1999	97	247	344	57,411	7,345	64,757	188	17,192	63,612
2000	110	272	382	58,390	7,345	65,735	172	19,096	70,656
2001	123	298	422	59,429	7,345	66,774	158	21,084	78,012
2002	135	321	455	60,532	7,345	67,877	149	22,752	84,183
2003	146	344	490	24,976	7,345	32,321	66	24,515	90,704
2004	158	369	528	26,219	7,345	33,564	64	26,377	97,597
2005	171	396	567	27,537	7,345	34,882	62	28,346	104,881
2006	184	424	609	28,937	7,345	36,282	60	30,427	112,581
2007	198	455	653	30,422	7,345	37,767	58	32,627	120,721
2008	212	487	699	31,999	7,345	39,344	56	34,953	129,326
2009	227	521	748	33,672	7,345	41,017	55	37,412	138,424
2010	243	557	800	35,448	7,345	42,793	53	40,011	148,042

Assumptions used for the benefit-cost analysis

Avoided cost of additional groundwater pumping ($/acre-foot):	$50
Avoided cost of surface water development ($/acre-foot):	$185
Discount rate:	3.00%
Benefit-cost ratio assuming continued groundwater pumping:	0.37
Benefit-cost ratio assuming surface water development:	1.38
Net present value assuming continued groundwater pumping:	$(461,897)
Net present value assuming surface water development:	$276,730

From an economic standpoint, the program's cost-effectiveness depends on how its benefits are estimated. This is illustrated in Table 5-2. Valuing the conserved water at the avoided cost of developing additional groundwater, or about $50 per acre-foot (Section 3), results in the program's costs exceeding its benefits.[11] Valuing the conserved water at the avoided cost of developing a surface water source, at a minimum of $185 per acre-foot (Section 3), results in the program showing significant net benefits.

BENEFIT-COST RATIO OF THE MODERATE PROGRAM

When conducting Urban Water Management Plans, the State Department of Water Resources (DWR) recommends that a benefit-cost ratio and net present value of each measure be estimated. Appendix A contains estimates of the benefit-cost ratio of each measure composing the Moderate program. This analysis is not concerned with these individual evaluations, preferring instead to look at the overall program. As previously mentioned, there are interrelationships among the individual measures that can only be appreciated when looking at the program as a whole.

A critical assumption in estimating a benefit cost ratio is the discount rate. Similar in concept to the interest rate, it describes the time value of money. Rather than specify different rates for the City and customer, as recommended by DWR, this analysis assumes an inflation-free discount rate of 3.0 percent.

The bottom portion of Table 5-2 summarizes the benefit-cost ratio and net present value of the Moderate program. Basing benefits on the avoided cost of additional groundwater development yields a benefit-cost ratio of 0.37. Generally, good economic investments have a benefit-cost ratio of 1.0 or higher, indicating that project benefits exceed costs. It is not surprising, then, that the net present value of the program is negative ($-461,897) when using the groundwater criteria.

Basing benefits on avoided costs of surface water development yields a benefit-cost ratio of 1.38 and a net present value of $276,730, signifying a worthwhile investment.

AGGRESSIVE PROGRAM EVALUATION

Table 5-3 summarizes the water conservation potential for the Aggressive program. The systemwide water savings varies from 90 acre-feet in 1991 to 880 acre-feet in 2010. Water savings due to the plumbing retrofit kits is approximately 13 acre-feet annually. The remaining two programs, multi-family and commercial landscape ordinance and

[11] It should be emphasized that this result does not imply that a water conservation plan should not be implemented. An Urban Water Management Plan serves two important purposes in addition to saving a scarce resource: (1) it may help to obtain future State aid for water supply or water treatment projects, such as State Revolving Funds, since it is unlikely that assistance will be offered a community without a water conservation plan; and (2) it will minimize any adverse water supply impacts resulting from Putah Creek adjudication or related litigation.

Table 5-3 Citywide Water Savings Through Conservation: Aggressive Program									
	Make Plumbing Retrofit Kits Available		Landscape Ordinance for Multi-Family and Commercial		Additional Public Education		Total Savings, When Combined With the Moderate Program		
Year	(acre-feet)	(gpcd)	(acre-feet)	(gpcd)	(acre-feet)	(gpcd)	(acre-feet)	(gpcd)	Percent Savings
1991	0	0.0	0	0.0	0	0.0	90	16	5.6
1992	13	2.2	6	1.0	6	1.0	127	22	7.6
1993	13	2.1	6	1.0	6	1.0	142	23	8.0
1994	13	2.0	6	1.0	6	1.0	157	25	8.4
1995	13	1.9	7	1.0	7	1.0	173	26	8.7
1996	13	1.8	7	1.0	7	1.0	266	38	12.7
1997	13	1.7	7	1.0	7	1.0	300	41	13.5
1998	13	1.6	8	1.0	8	1.0	336	43	14.3
1999	13	1.6	8	1.0	8	1.0	373	46	15.0
2000	13	1.5	9	1.0	9	1.0	412	48	15.6
2001	13	1.4	9	1.0	9	1.0	452	50	16.1
2002	13	1.4	9	1.0	9	1.0	487	52	16.3
2003	13	1.3	10	1.0	10	1.0	523	53	16.5
2004	13	1.2	10	1.0	10	1.0	561	54	16.6
2005	13	1.2	11	1.0	11	1.0	602	55	16.7
2006	13	1.1	11	1.0	11	1.0	644	56	16.8
2007	13	1.1	12	1.0	12	1.0	689	57	16.8
2008	13	1.0	13	1.0	13	1.0	737	58	16.8
2009	13	1.0	13	1.0	13	1.0	788	59	16.7
2010	13	0.9	14	1.0	14	1.0	841	60	16.6

additional public education, show similar savings ranging from 6 acre-feet in 1992 to 16 acre-feet in 2010.

Overall, the Aggressive program is anticipated to reduce 1991 demand by about 6 percent compared to the baseline scenario. The savings increase to about 17 percent below the baseline in 2010. These savings are significant but not appreciably greater than the savings attributable to the Moderate program.

BENEFIT-COST RATIO OF THE AGGRESSIVE PROGRAM

The benefit-cost ratios of the program are 0.37 and 1.36 when valuing conserved water at the avoided cost of groundwater and surface water, respectively (Table 5-4). The present value of the program (based on these two water supply options) ranges from about $-506,285 to about $285,062. Like the Moderate program, the cost-effectiveness of the Aggressive program is sensitive to how the alternative water source is valued.

The cost per acre-foot of water conserved ranges from nearly $454 in 1993 to a low of $56 in 2010, which is comparable to the Moderate program.

MAXIMUM PROGRAM EVALUATION

Use is reduced up to nearly 29 percent under the Maximum program (Table 5-5). Substantial savings are realized from both the landscape ordinance on new construction and the use of water pricing incentives. Estimated systemwide reductions in water use vary from about 100 acre-feet (18 gpcd) in 1991, or 6 percent below baseline usage, to about 1,500 acre-feet (107 gpcd) in 2010, 29 to 30 percent of baseline water use.

BENEFIT-COST RATIO OF THE MAXIMUM PROGRAM

Similar to the other programs, the benefit-cost ratio of the Maximum program is less than one (0.51) when additional groundwater development is viewed as the alternative water source, and greater than one when surface water importation is considered as the alternative (1.89) (Table 5-6). The lower benefit-cost ratio corresponds to a negative net present value of the Maximum program ($-442,025), and the higher ratio corresponds to a net present value of $808,673.

Table 5-4 Economic Evaluation of the Aggressive Conservation Program									
Year	Total Savings (acre-feet)			Program Costs ($)			Costs per Acre-Foot Conserved ($)	Benefits of Program ($), Based on the Cost of	
	Indoor Uses	Outdoor Uses	Total	City Outlays	Customer Costs	Total		Groundwater	Surface Water
1991	7	83	90	8,750	7,345	16,095	179	4,493	16,624
1992	12	91	103	20,250	11,018	31,268	304	5,147	19,046
1993	33	108	141	56,620	7,345	63,965	454	7,051	26,087
1994	39	117	156	57,305	7,345	64,650	414	7,812	28,903
1995	45	127	172	70,140	7,345	77,486	450	8,617	31,882
1996	77	188	265	58,802	7,345	66,147	250	13,246	49,009
1997	89	211	299	59,621	7,345	66,966	224	14,957	55,341
1998	101	234	335	60,489	7,345	67,834	203	16,741	61,942
1999	114	258	372	61,411	7,345	68,757	185	18,602	68,808
2000	127	284	411	62,390	7,345	69,735	170	20,545	76,017
2001	140	311	451	63,429	7,345	70,774	157	22,575	83,526
2002	152	334	486	64,532	7,345	71,877	148	24,286	89,858
2003	164	358	522	28,976	7,345	36,321	70	26,094	96,548
2004	176	384	560	30,219	7,345	37,564	67	28,005	103,617
2005	189	412	600	31,537	7,345	38,882	65	30,024	111,088
2006	202	441	643	32,937	7,345	40,282	63	32,158	118,983
2007	216	472	688	34,422	7,345	41,767	61	34,413	127,329
2008	231	505	736	35,999	7,345	43,344	59	36,797	136,150
2009	247	540	786	37,672	7,345	45,017	57	39,317	145,474
2010	263	577	840	39,448	7,345	46,793	56	41,981	155,331

Assumptions used for the benefit-cost analysis

Avoided cost of additional groundwater pumping ($/acre-foot):	$50
Avoided cost of surface water development ($/acre-foot):	$185
Discount rate:	3.00%
Benefit-cost ratio assuming continued groundwater pumping:	0.37
Benefit-cost ratio assuming surface water development:	1.36
Net present value assuming continued groundwater pumping:	$(506,285)
Net present value assuming surface water development:	$285,062

Table 5-5 Citywide Water Savings Through Conservation: Maximum Program							
Year	Landscape Ordinance		Water Pricing Incentives		Total Savings, When Combined with the Aggressive Program		Percent Savings
	(acre-feet)	(gpcd)	(acre-feet)	(gpcd)	(acre-feet)	(gpcd)	
1991	8	1.5	0	0.0	98	18	6.1
1992	16	2.8	0	0.0	143	25	8.5
1993	25	4.1	0	0.0	167	28	9.4
1994	34	5.4	0	0.0	191	30	10.2
1995	44	6.6	0	0.0	217	33	10.9
1996	54	7.7	43	6.2	363	52	17.3
1997	65	8.8	60	8.2	425	58	19.2
1998	76	9.8	81	10.5	492	64	21.0
1999	88	10.8	105	13.0	566	70	22.7
2000	100	11.7	133	15.6	645	76	24.4
2001	113	12.6	151	16.8	716	80	25.6
2002	127	13.4	169	17.9	782	83	26.3
2003	141	14.2	188	19.0	852	86	26.9
2004	156	15.0	208	20.0	926	89	27.4
2005	172	15.7	229	21.0	1,003	92	27.9
2006	189	16.4	252	21.9	1,085	94	28.2
2007	206	17.1	275	22.8	1,171	97	28.5
2008	225	17.7	299	23.6	1,261	99	28.7
2009	244	18.3	325	24.4	1,357	102	28.8
2010	264	18.9	352	25.2	1,458	104	28.8

Table 5-6 Economic Evaluation of the Maximum Conservation Program										
Year	Total Savings (acre-feet)			Program Costs ($)			Costs per Acre-Foot Conserved ($)	Benefits of Program ($), Based on the Cost of	
	Indoor Uses	Outdoor Uses	Total	City Outlays	Customer Costs	Total		Groundwater	Surface Water
1991	7	91	98	13,750	7,345	21,095	216	4,889	18,090
1992	12	107	119	25,250	11,018	36,268	304	5,960	22,052
1993	33	133	166	61,620	7,345	68,965	415	8,301	30,712
1994	39	151	190	62,305	7,345	69,650	366	9,522	35,230
1995	45	171	216	75,140	7,345	82,486	382	10,810	39,996
1996	98	264	362	78,802	7,345	86,147	238	18,107	66,995
1997	119	305	424	66,621	7,345	73,966	174	21,209	78,475
1998	141	350	492	67,489	7,345	74,834	152	24,583	90,957
1999	166	399	565	68,411	7,345	75,757	134	28,246	104,510
2000	193	451	644	69,390	7,345	76,735	119	32,218	119,205
2001	216	500	715	70,429	7,345	77,774	109	35,764	132,329
2002	236	545	781	71,532	7,345	78,877	101	39,070	144,560
2003	258	593	851	35,976	7,345	43,321	51	42,554	157,450
2004	280	644	925	37,219	7,345	44,564	48	46,225	171,034
2005	304	698	1,002	38,537	7,345	45,882	46	50,095	185,350
2006	328	755	1,083	39,937	7,345	47,282	44	54,173	200,439
2007	354	816	1,169	41,422	7,345	48,767	42	58,471	216,343
2008	381	879	1,260	42,999	7,345	50,344	40	63,002	233,107
2009	409	946	1,356	44,672	7,345	52,017	38	67,778	250,777
2010	439	1,017	1,456	46,448	7,345	53,793	37	72,812	269,404

Assumptions used for the benefit-cost analysis

Avoided cost of additional groundwater pumping ($/acre-foot):	$50
Avoided cost of surface water development ($/acre/foot):	$185
Discount rate:	3.00%
Benefit-cost ratio assuming continued groundwater pumping:	0.51
Benefit-cost ratio assuming surface water development:	1.89
Net present value assuming continued groundwater pumping:	$(442,025)
Net present value assuming surface water development:	$808,673

6. CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

Long-run estimates of water savings due to implementation of a conservation program vary from 16 percent below anticipated baseline usage under the Moderate program, to nearly 29 percent below baseline under the Maximum program. The Aggressive program, a compromise between the other two, realizes an estimated savings of 17 percent below baseline water use.

The economic feasibility of implementing either of the conservation programs is sensitive to how the benefits of conservation are estimated. Traditionally, the per-acre-foot benefits are valued at the avoided cost of developing other sources of water. For Winters, the avoided cost can range from about $50 per acre-foot for developing additional groundwater, to a minimum of $185 per acre-foot for treating and importing surface water sources. Using the standard benefit-cost and net present value approaches, this analysis determined that all of the conservation programs have a benefit-cost ratio of less than one when using additional groundwater development to value the conserved water. However, valuing conservation at the cost of surface water results in a benefit-cost ratios of greater than one for all three programs.

Figure 6-1 shows the cost of each conservation program in terms of cost per acre-foot conserved. For all programs, there are initial start-up costs, especially over the first 5 years of implementation. However, after this initial period the per acre-foot costs drop significantly, tending to stabilize at about $60 per acre-foot for all alternatives.

Figure 6-2 compares water use under each of the three conservation programs to baseline water use developed in Section 2. Each program demonstrates a significant reduction below baseline levels. Implementation of any of the three programs will result in prolonged life of the underlying groundwater aquifer and ensure Winters of adequate future water supplies.

RECOMMENDATIONS

It is recommended that the City implement the Moderate conservation program immediately. This program features the lowest initial costs of the three programs and shows potential for significant water savings. This program will have minimal impacts on the lifestyle of current residents. With the exception of the alternate-day lawn watering measure, little resistance to the program is expected.

It is further recommended that the City take two additional steps to assure success of the conservation program:

1. Monitor water usage, to the best of the City's ability, and annually assess the Moderate program. If the program is found to conserve less than estimated, or if growth within the City is higher than anticipated, it is recommended that

selected portions of the Aggressive or Moderate programs be implemented to supplement the Moderate program.

2. Continually re-assess the proportion of residential water use to total water use. Most of the conservation measures are targeted at the residential sector. If the proportion of residential use to total use declines over time, it may be necessary to develop new conservation measures targeted at other types of water uses, such as industrial or commercial.

Figure 6-1
CONSERVATION COSTS PER ACRE-FOOT

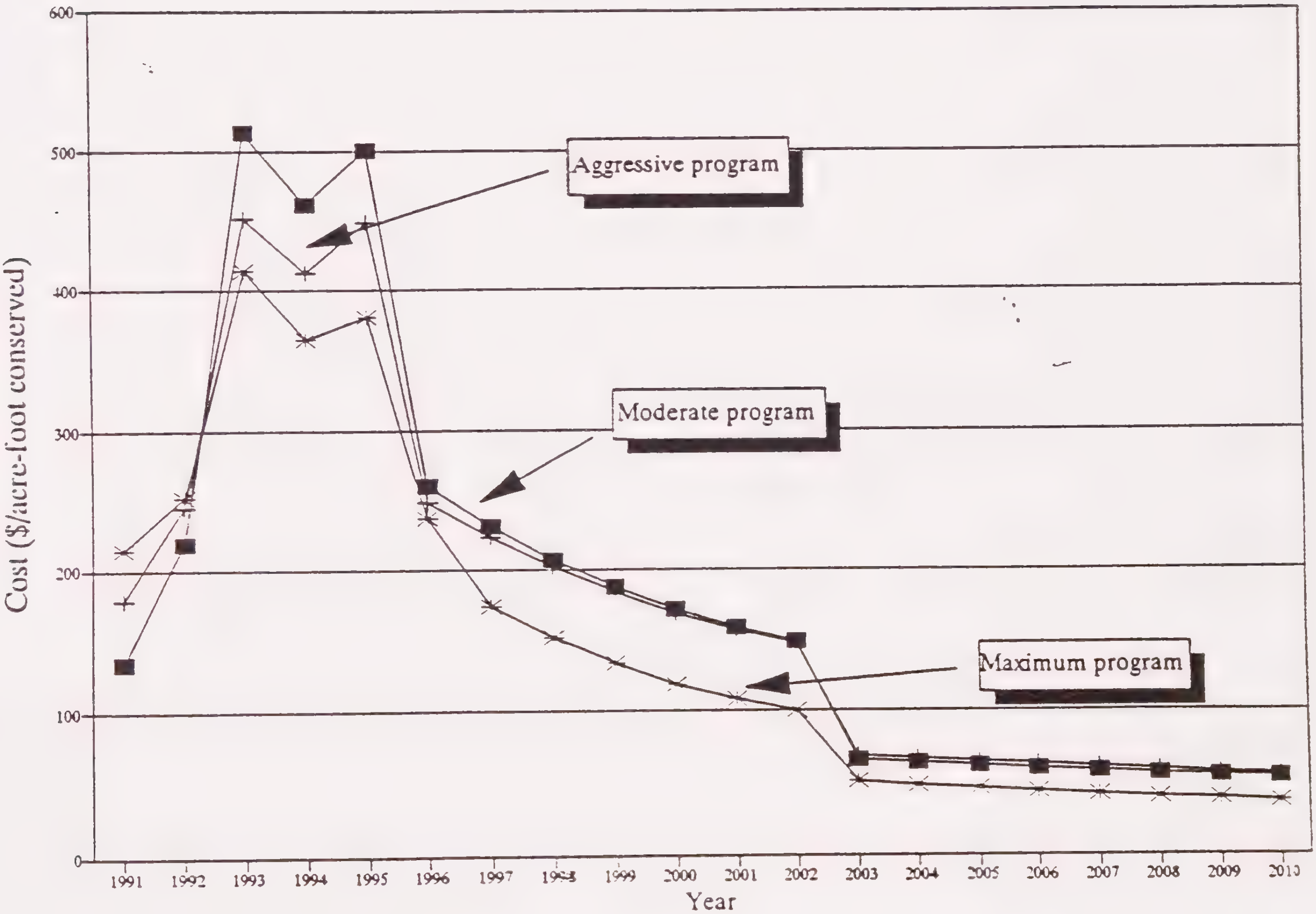
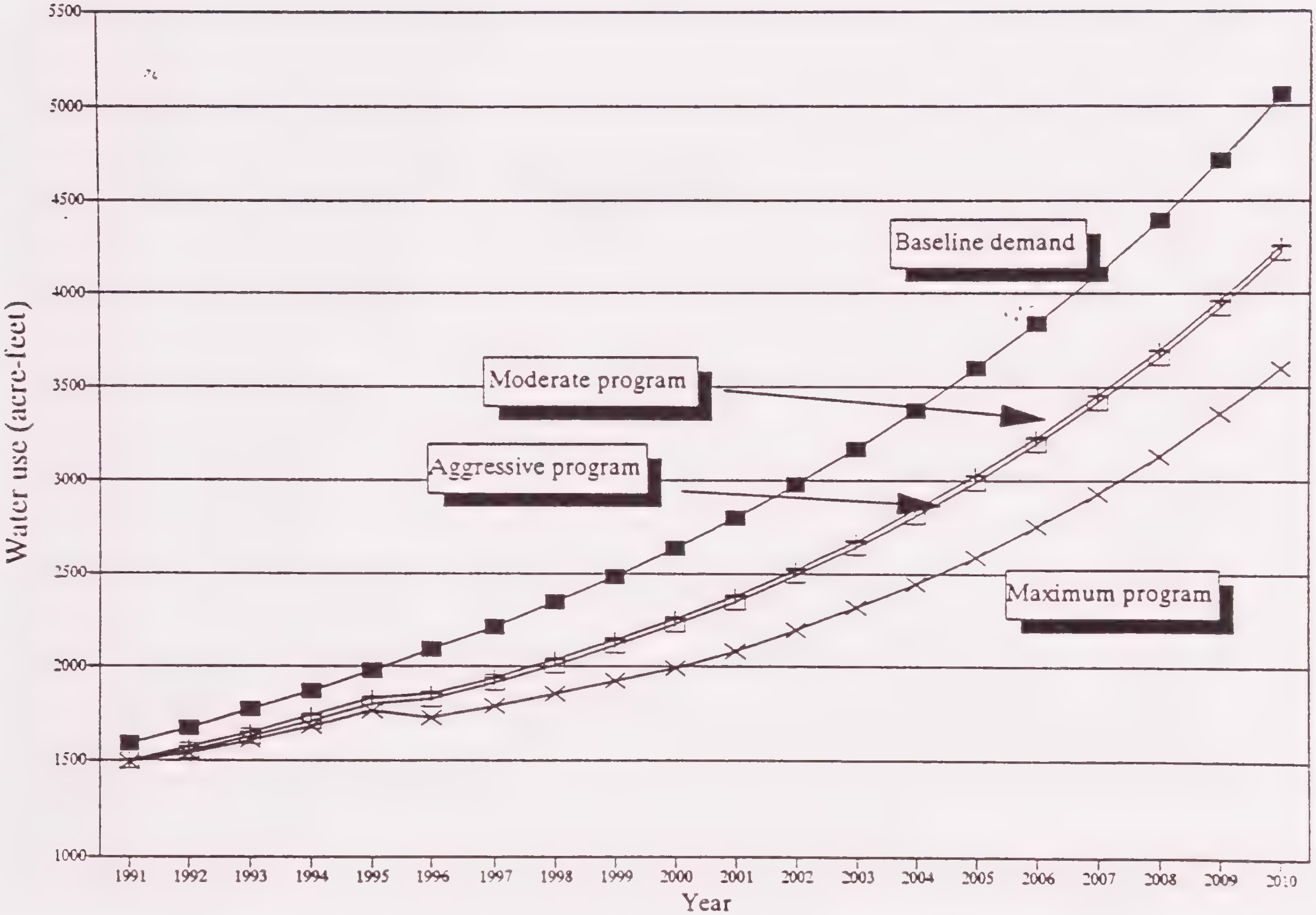


Figure 6-2
ESTIMATED WATER USAGE



Appendix A

PROGRAM ANALYSIS: MODERATE PROGRAM

PROGRAM ANALYSIS: MODERATE PROGRAM

Measure: Low flow plumbing in new housing; 2.5 gpm showers, 1.6 gal toilets, low flow appliances

Sectors effected: All sectors; mostly residential housing

Assumptions: Water savings is estimated to be about 13 gpcd for new residences and businesses

Year	Participation % of new structures	Water savings (gpcd)	Effective savings (gpcd)	City wide savings: million gallons	Acre-feet	Implemention costs: City outlay	Customer	Benefits of measure based on avoided cost groundwater	surface water
1991	100%	13	13	1.119	3.434	$750	$0	$172	$635
1992	100%	13	13	2.295	7.042	$750	$0	$352	$1,303
1993	100%	13	13	3.530	10.834	$750	$0	$542	$2,004
1994	100%	13	13	4.829	14.819	$750	$0	$741	$2,741
1995	100%	13	13	6.193	19.005	$750	$0	$950	$3,516
1996	100%	13	13	7.627	23.405	$750	$0	$1,170	$4,330
1997	100%	13	13	9.133	28.028	$750	$0	$1,401	$5,185
1998	100%	13	13	10.716	32.886	$750	$0	$1,644	$6,084
1999	100%	13	13	12.379	37.990	$750	$0	$1,900	$7,028
2000	100%	13	13	14.127	43.354	$750	$0	$2,168	$8,021
2001	100%	13	13	15.964	48.991	$750	$0	$2,450	$9,063
2002	100%	13	13	17.894	54.914	$750	$0	$2,746	$10,159
2003	100%	13	13	19.922	61.137	$750	$0	$3,057	$11,310
2004	100%	13	13	22.053	67.677	$750	$0	$3,384	$12,520
2005	100%	13	13	24.292	74.549	$750	$0	$3,727	$13,792
2006	100%	13	13	26.645	81.770	$750	$0	$4,089	$15,127
2007	100%	13	13	29.117	89.358	$750	$0	$4,468	$16,531
2008	100%	13	13	31.716	97.331	$750	$0	$4,867	$18,006
2009	100%	13	13	34.446	105.710	$750	$0	$5,285	$19,556
2010	100%	13	13	37.314	114.514	$750	$0	$5,726	$21,185

Assumptions for estimating benefits and the benefit cost ratio

Avoided cost of groundwater=	$50
Avoided cost of surface water:	$185
Discount rate	3.0%

Benefit cost ratio of the conservation measure:

B/C ratio based on avoided cost of groundwater:

City perspective	3.0
Customer perspective	ERR

B/C ratio based on avoided cost of surface water:

City perspective	11.2
Customer perspective	ERR

Note: "ERR" denotes division by 0.

PROGRAM ANALYSIS: MODERATE PROGRAM

Measure: Low flow plumbing in new housing; 2.5 gpm showers, 1.6 gal toilets, low flow appliances

Sectors effected: All sectors; mostly residential housing

Assumptions: Water savings is estimated to be about 13 gpcd for new residences and businesses

Year	Participation % of new structures	Water savings (gpcd)	Effective savings (gpcd)	City wide savings: million gallons	Acre-feet	Implemention costs: City outlay	Customer	Benefits of measure based on avoided cost groundwater	surface water
1991	100%	13	13	1.119	3.434	$750	$0	$172	$635
1992	100%	13	13	2.295	7.042	$750	$0	$352	$1,303
1993	100%	13	13	3.530	10.834	$750	$0	$542	$2,004
1994	100%	13	13	4.829	14.819	$750	$0	$741	$2,741
1995	100%	13	13	6.193	19.005	$750	$0	$950	$3,516
1996	100%	13	13	7.627	23.405	$750	$0	$1,170	$4,330
1997	100%	13	13	9.133	28.028	$750	$0	$1,401	$5,185
1998	100%	13	13	10.716	32.886	$750	$0	$1,644	$6,084
1999	100%	13	13	12.379	37.990	$750	$0	$1,900	$7,028
2000	100%	13	13	14.127	43.354	$750	$0	$2,168	$8,021
2001	100%	13	13	15.964	48.991	$750	$0	$2,450	$9,063
2002	100%	13	13	17.894	54.914	$750	$0	$2,746	$10,159
2003	100%	13	13	19.922	61.137	$750	$0	$3,057	$11,310
2004	100%	13	13	22.053	67.677	$750	$0	$3,384	$12,520
2005	100%	13	13	24.292	74.549	$750	$0	$3,727	$13,792
2006	100%	13	13	26.645	81.770	$750	$0	$4,089	$15,127
2007	100%	13	13	29.117	89.358	$750	$0	$4,468	$16,531
2008	100%	13	13	31.716	97.331	$750	$0	$4,867	$18,006
2009	100%	13	13	34.446	105.710	$750	$0	$5,285	$19,556
2010	100%	13	13	37.314	114.514	$750	$0	$5,726	$21,185

Assumptions for estimating benefits and the benefit cost ratio

Avoided cost of groundwater=	$50
Avoided cost of surface water:	$185
Discount rate	3.0%

Benefit cost ratio of the conservation measure:

B/C ratio based on avoided cost of groundwater:

City perspective	3.0
Customer perspective	ERR

B/C ratio based on avoided cost of surface water:

City perspective	11.2
Customer perspective	ERR

Note: "ERR" denotes division by 0.

Measure: Require low-flow plumbing fixtures be retrofit when current fixtures wear-out (min. of low flow showerheads, 1.6 gal toilets, faucet aerators installed)

Sectors effected: All sectors; mostly existing residential housing

Assumptions: Assumes toilet replacement every 30 years, 1.5 toilets per household, $100 in additional cost to the customer per toilet;showerhead replacement every 10 years

Water saving is assumed to be less than that for new housing; no marginal cost to the City to implement this measure.

Year	Participation	Water	Effective	City wide savings:		Implemention costs:		Benefits of measure	
	% of existing	savings	savings	million	Acre-	City outlay	Customer	based on avoided cost	
	structures	(gpcd)	(gpcd)	gallons	feet		(add'n costs)	groundwater	surface water
1991	3%	10	0.333	0.565	1.733	$0	$7,345	$87	$321
1992	7%	10	0.667	1.130	3.467	$0	$7,345	$173	$641
1993	10%	10	1.000	1.694	5.200	$0	$7,345	$260	$962
1994	13%	10	1.333	2.259	6.933	$0	$7,345	$347	$1,283
1995	17%	10	1.667	2.824	8.667	$0	$7,345	$433	$1,603
1996	20%	10	2.000	3.389	10.400	$0	$7,345	$520	$1,924
1997	23%	10	2.333	3.954	12.133	$0	$7,345	$607	$2,245
1998	27%	10	2.667	4.518	13.866	$0	$7,345	$693	$2,565
1999	30%	10	3.000	5.083	15.600	$0	$7,345	$780	$2,886
2000	33%	10	3.333	5.648	17.333	$0	$7,345	$867	$3,207
2001	37%	10	3.667	6.213	19.066	$0	$7,345	$953	$3,527
2002	40%	10	4.000	6.778	20.800	$0	$7,345	$1,040	$3,848
2003	43%	10	4.333	7.342	22.533	$0	$7,345	$1,127	$4,169
2004	47%	10	4.667	7.907	24.266	$0	$7,349	$1,213	$4,489
2005	50%	10	5.000	8.472	26.000	$0	$7,345	$1,300	$4,810
2006	53%	10	5.333	9.037	27.733	$0	$7,345	$1,387	$5,131
2007	57%	10	5.667	9.602	29.466	$0	$7,345	$1,473	$5,451
2008	60%	10	6.000	10.166	31.199	$0	$7,345	$1,560	$5,772
2009	63%	10	6.333	10.731	32.933	$0	$7,345	$1,647	$6,093
2010	67%	10	6.667	11.296	34.666	$0	$7,345	$1,733	$6,413

Assumptions for estimating benefits and the benefit cost ratio

Avoided cost of groundwater=	$50
Avoided cost of surface water:	$185
Discount rate	3.0%

Benefit cost ratio of the conservation measure:

B/C ratio based on avoided cost of groundwater:

City perspective	ERR
Customer perspective	0.1

B/C ratio based on avoided cost of surface water:

City perspective	ERR
Customer perspective	0.4

Measure: Alternate day lawn watering, odd/even, no watering between 10 and 6 during summer months

Sectors effected: All

Assumptions: Cuts outdoor use about 20 percent; compliance increases annually

However, enforcement will require about $1000 annually

Year	Participation % of all customers	Water savings (gpcd)	Effective savings (gpcd)	City wide savings: million gallons	Acre-feet	Implemention costs: City outlay	Customer	Benefits of measure based on avoided cost groundwater	surface water
1991	50%	30	15.000	26.707	81.961	$1,000	$0	$4,098	$15,163
1992	52%	30	15.600	29.186	89.570	$1,000	$0	$4,478	$16,570
1993	54%	30	16.200	31.849	97.740	$1,000	$0	$4,887	$18,082
1994	56%	30	16.800	34.706	106.509	$1,000	$0	$5,325	$19,704
1995	58%	30	17.400	37.771	115.916	$1,000	$0	$5,796	$21,445
1996	60%	30	18.000	41.059	126.005	$1,000	$0	$6,300	$23,311
1997	62%	30	18.600	44.583	136.820	$1,000	$0	$6,841	$25,312
1998	64%	30	19.200	48.359	148.408	$1,000	$0	$7,420	$27,455
1999	66%	30	19.800	52.404	160.820	$1,000	$0	$8,041	$29,752
2000	68%	30	20.400	56.734	174.111	$1,000	$0	$8,706	$32,211
2001	70%	30	21.000	61.370	188.337	$1,000	$0	$9,417	$34,842
2002	72%	30	21.600	66.330	203.559	$1,000	$0	$10,178	$37,658
2003	74%	30	22.200	71.636	219.841	$1,000	$0	$10,992	$40,671
2004	76%	30	22.800	77.309	237.253	$1,000	$0	$11,863	$43,892
2005	78%	30	23.400	83.374	255.866	$1,000	$0	$12,793	$47,335
2006	80%	30	24.000	89.856	275.758	$1,000	$0	$13,788	$51,015
2007	82%	30	24.600	96.781	297.010	$1,000	$0	$14,851	$54,947
2008	84%	30	25.200	104.178	319.711	$1,000	$0	$15,986	$59,146
2009	86%	30	25.800	112.077	343.951	$1,000	$0	$17,198	$63,631
2010	88%	30	26.400	120.509	369.829	$1,000	$0	$18,491	$68,418

Assumptions for estimating benefits and the benefit cost ratio

Avoided cost of groundwater=	$50
Avoided cost of surface water:	$185
Discount rate	3.0%

Benefit cost ratio of the conservation measure:

B/C ratio based on avoided cost of groundwater:

City perspective	9.2
Customer perspective	ERR

B/C ratio based on avoided cost of surface water:

City perspective	33.9
Customer perspective	ERR

Measure: Public education program

Sectors effected: All

Assumptions: Might includes local newspaper blitz; Water Awareness Week for schools and poster contest; guest speakers for schools; xeriscape promotion; Dist'n of outdoor watering and plant guides. Water savings is minimal, about .5 gpcd, but measure is necessary for overall program.

Year	Participation % of all customers	Water savings (gpcd)	Effective savings (gpcd)	City wide savings: million gallons	Acre-feet	Implemention costs: City outlay	Customer	Benefits of measure based on avoided cost groundwater	surface water
1991	100%	0.5	0.500	0.890	2.732	$3,000	$0	$137	$505
1992	100%	0.5	0.500	0.935	2.871	$3,000	$0	$144	$531
1993	100%	0.5	0.500	0.983	3.017	$3,000	$0	$151	$558
1994	100%	0.5	0.500	1.033	3.170	$3,000	$0	$158	$586
1995	100%	0.5	0.500	1.085	3.331	$3,000	$0	$167	$616
1996	100%	0.5	0.500	1.141	3.500	$3,000	$0	$175	$648
1997	100%	0.5	0.500	1.198	3.678	$3,000	$0	$184	$680
1998	100%	0.5	0.500	1.259	3.865	$3,000	$0	$193	$715
1999	100%	0.5	0.500	1.323	4.061	$3,000	$0	$203	$751
2000	100%	0.5	0.500	1.391	4.267	$3,000	$0	$213	$789
2001	100%	0.5	0.500	1.461	4.484	$3,000	$0	$224	$830
2002	100%	0.5	0.500	1.535	4.712	$3,000	$0	$236	$872
2003	100%	0.5	0.500	1.613	4.951	$3,000	$0	$248	$916
2004	100%	0.5	0.500	1.695	5.203	$3,000	$0	$260	$963
2005	100%	0.5	0.500	1.781	5.467	$3,000	$0	$273	$1,011
2006	100%	0.5	0.500	1.872	5.745	$3,000	$0	$287	$1,063
2007	100%	0.5	0.500	1.967	6.037	$3,000	$0	$302	$1,117
2008	100%	0.5	0.500	2.067	6.343	$3,000	$0	$317	$1,174
2009	100%	0.5	0.500	2.172	6.666	$3,000	$0	$333	$1,233
2010	100%	0.5	0.500	2.282	7.004	$3,000	$0	$350	$1,296

Assumptions for estimating benefits and the benefit cost ratio

Avoided cost of groundwater=	$50
Avoided cost of surface water:	$185
Discount rate	3.0%

Benefit cost ratio of the conservation measure:

B/C ratio based on avoided cost of groundwater:

City perspective	0.1
Customer perspective	ERR

B/C ratio based on avoided cost of surface water:

City perspective	0.3
Customer perspective	ERR

Measure: Metering new construction

Sectors effected: All

Assumptions: All new construction is metered; meters are read in 1996 and beyond

A rate study is assumed to be needed in 1995; meter cost is assumed to be $125 per structure

When combined with other measures, water savings is assumed to be about 10 percent of outdoor use

Year	Participation % of new structures	Water savings (gpcd)	Effective savings (gpcd)	City wide savings: million gallons	Acre-feet	Implemention costs: City outlay	Customer	Benefits of measure based on avoided cost groundwater	surface water
1991	100%	15	0.000	0.000	0.000	$0	$0	$0	$0
1992	100%	15	0.000	0.000	0.000	$10,500	$0	$0	$0
1993	100%	15	0.000	0.000	0.000	$11,145	$0	$0	$0
1994	100%	15	0.000	0.000	0.000	$11,829	$0	$0	$0
1995	100%	15	0.000	0.000	0.000	$24,665	$0	$0	$0
1996	100%	15	15.000	11.263	34.565	$13,327	$0	$1,728	$6,395
1997	100%	15	15.000	13.870	42.566	$14,145	$0	$2,128	$7,875
1998	100%	15	15.000	16.610	50.974	$15,014	$0	$2,549	$9,430
1999	100%	15	15.000	19.489	59.809	$15,936	$0	$2,990	$11,065
2000	100%	15	15.000	22.514	69.093	$16,915	$0	$3,455	$12,782
2001	100%	15	15.000	25.693	78.848	$17,953	$0	$3,942	$14,587
2002	100%	15	15.000	29.033	89.099	$19,056	$0	$4,455	$16,483
2003	100%	15	15.000	32.543	99.871	$20,226	$0	$4,994	$18,476
2004	100%	15	15.000	36.231	111.190	$21,469	$0	$5,559	$20,570
2005	100%	15	15.000	40.107	123.083	$22,787	$0	$6,154	$22,770
2006	100%	15	15.000	44.179	135.582	$24,187	$0	$6,779	$25,083
2007	100%	15	15.000	48.459	148.715	$25,672	$0	$7,436	$27,512
2008	100%	15	15.000	52.956	162.515	$27,249	$0	$8,126	$30,065
2009	100%	15	15.000	57.681	177.016	$28,922	$0	$8,851	$32,748
2010	100%	15	15.000	62.646	192.254	$30,698	$0	$9,613	$35,567

Assumptions for estimating benefits and the benefit cost ratio

Avoided cost of groundwater=	$50
Avoided cost of surface water:	$185
Discount rate	3.0%

Benefit cost ratio of the conservation measure:

B/C ratio based on avoided cost of groundwater:

City perspective	0.2
Customer perspective	ERR

B/C ratio based on avoided cost of surface water:

City perspective	0.7
Customer perspective	ERR

Measure: Retrofit current structures with meters in conjunction with the main replacement program

Sectors effected: All, mostly residential

Assumptions: All new construction is metered; older structures are metered over a 10 year period 1992-2001;

Meter reading begins in 1995; Savings is assumed to be about 10 percent of outdoor use; Meter cost is assumed to be $250

Year	Participation % of existing structures	Water savings (gpcd)	Effective savings (gpcd)	City wide savings: million gallons	Acre-feet	Implemention costs: City outlay	Customer	Benefits of measure based on avoided cost groundwater	surface water
1991	0%	15	0.000	0.000	0.000	$0	$0	$0	$0
1992	10%	15	1.500	0.000	0.000	$36,725	$0	$0	$0
1993	20%	15	3.000	0.000	0.000	$36,725	$0	$0	$0
1994	30%	15	4.500	0.000	0.000	$36,725	$0	$0	$0
1995	40%	15	6.000	0.000	0.000	$36,725	$0	$0	$0
1996	50%	15	7.500	13.354	40.980	$36,725	$0	$2,049	$7,581
1997	60%	15	9.000	16.024	49.177	$36,725	$0	$2,459	$9,098
1998	70%	15	10.500	18.695	57.373	$36,725	$0	$2,869	$10,614
1999	80%	15	12.000	21.366	65.569	$36,725	$0	$3,278	$12,130
2000	90%	15	13.500	24.036	73.765	$36,725	$0	$3,688	$13,646
2001	100%	15	15.000	26.707	81.961	$36,725	$0	$4,098	$15,163
2002	100%	15	15.000	26.707	81.961	$0	$0	$4,098	$15,163
2003	100%	15	15.000	26.707	81.961	$0	$0	$4,098	$15,163
2004	100%	15	15.000	26.707	81.961	$0	$0	$4,098	$15,163
2005	100%	15	15.000	26.707	81.961	$0	$0	$4,098	$15,163
2006	100%	15	15.000	26.707	81.961	$0	$0	$4,098	$15,163
2007	100%	15	15.000	26.707	81.961	$0	$0	$4,098	$15,163
2008	100%	15	15.000	26.707	81.961	$0	$0	$4,098	$15,163
2009	100%	15	15.000	26.707	81.961	$0	$0	$4,098	$15,163
2010	100%	15	15.000	26.707	81.961	$0	$0	$4,098	$15,163

Assumptions for estimating benefits and the benefit cost ratio

Avoided cost of groundwater=	$50
Avoided cost of surface water:	$185
Discount rate	3.0%

Benefit cost ratio of the conservation measure:

B/C ratio based on avoided cost of groundwater:

City perspective	0.1
Customer perspective	ERR

B/C ratio based on avoided cost of surface water:

City perspective	0.5
Customer perspective	ERR

Subtotal of water savings due to moderate program

Year	Acre-feet conserved (acre-feet)	New demand (acre-feet)	Safe annual yield (acre-feet)	Baseline usage (gpcd)	"Moderate" usage (gpcd)	Implementation costs: City ($)	Customers ($)	Cost per AF conserved ($)
1991	90	1,503	4,000	291	275	$4,750	$7,345	$135
1992	103	1,578	4,000	293	275	$15,250	$7,345	$219
1993	117	1,658	4,000	294	275	$52,620	$7,345	$513
1994	131	1,743	4,000	296	275	$53,305	$7,345	$461
1995	147	1,834	4,000	297	275	$66,140	$7,345	$500
1996	239	1,856	4,000	299	265	$54,802	$7,345	$260
1997	272	1,945	4,000	301	264	$55,621	$7,345	$231
1998	307	2,041	4,000	304	264	$56,489	$7,345	$208
1999	344	2,145	4,000	306	264	$57,411	$7,345	$188
2000	382	2,258	4,000	309	265	$58,390	$7,345	$172
2001	422	2,381	4,000	313	265	$59,429	$7,345	$158
2002	455	2,523	4,000	316	268	$60,532	$7,345	$149
2003	490	2,678	4,000	320	270	$24,976	$7,345	$66
2004	528	2,846	4,000	324	274	$26,219	$7,345	$64
2005	567	3,030	4,000	329	277	$27,537	$7,345	$62
2006	609	3,231	4,000	334	281	$28,937	$7,345	$60
2007	653	3,451	4,000	340	286	$30,422	$7,345	$58
2008	699	3,694	4,000	346	291	$31,999	$7,345	$56
2009	748	3,961	4,000	353	297	$33,672	$7,345	$55
2010	800	4,256	4,000	361	304	$35,448	$7,345	$53

Appendix B

PROGRAM ANALYSIS: AGGRESSIVE PROGRAM

PROGRAM ANALYSIS: AGGRESSIVE PROGRAM

This assumes the measures from the Moderate Program plus additional measures

Measure: Make good quality retrofit kits available for purchase to Winters customers, over a 1 year period. Kits include 1 2.5 gpm showerhead, faucet aerators, leak detection tabs, 1 toilet dam.

Sectors effected: All existing structures

Assumptions: Up to 25 percent of curretn customers ultimately buy the plumbing devices. Need to be cautious not to double count from retrofit ordinance.

The City arranges with a wholesaler to make the kits available at a discounted price of $10 per kit.

Year	Participation % of existing customers	Water savings (gpcd)	Effective savings (gpcd)	City wide savings: million gallons	Acre-feet	Implemention costs: City outlay	Customer	Benefits of measure based on avoided cost groundwater	surface water
1991	0%	10	0.000	0.000	0.000	$0	$0	$0	$0
1992	25%	10	2.500	4.150	12.736	$1,000	$3,673	$637	$2,356
1993	25%	10	2.500	4.150	12.736	$0	$0	$637	$2,356
1994	25%	10	2.500	4.150	12.736	$0	$0	$637	$2,356
1995	25%	10	2.500	4.150	12.736	$0	$0	$637	$2,356
1996	25%	10	2.500	4.150	12.736	$0	$0	$637	$2,356
1997	25%	10	2.500	4.150	12.736	$0	$0	$637	$2,356
1998	25%	10	2.500	4.150	12.736	$0	$0	$637	$2,356
1999	25%	10	2.500	4.150	12.736	$0	$0	$637	$2,356
2000	25%	10	2.500	4.150	12.736	$0	$0	$637	$2,356
2001	25%	10	2.500	4.150	12.736	$0	$0	$637	$2,356
2002	25%	10	2.500	4.150	12.736	$0	$0	$637	$2,356
2003	25%	10	2.500	4.150	12.736	$0	$0	$637	$2,356
2004	25%	10	2.500	4.150	12.736	$0	$0	$637	$2,356
2005	25%	10	2.500	4.150	12.736	$0	$0	$637	$2,356
2006	25%	10	2.500	4.150	12.736	$0	$0	$637	$2,356
2007	25%	10	2.500	4.150	12.736	$0	$0	$637	$2,356
2008	25%	10	2.500	4.150	12.736	$0	$0	$637	$2,356
2009	25%	10	2.500	4.150	12.736	$0	$0	$637	$2,356
2010	25%	10	2.500	4.150	12.736	$0	$0	$637	$2,356

Assumptions for estimating benefits and the benefit cost ratio

Avoided cost of groundwater=	$50
Avoided cost of surface water:	$185
Discount rate	3.0%

Benefit cost ratio of the conservation measure:

B/C ratio based on avoided cost of groundwater:

City perspective	9.4
Customer perspective	2.6

B/C ratio based on avoided cost of surface water:

City perspective	34.8
Customer perspective	9.5

Measure: Landscape ordinance for commercial and MF housing

Sectors effected: Commercial and MF housing

Assumptions

Year	Participation % of total customers	Water savings (gpcd)	Effective savings (gpcd)	City wide savings: million gallons	Acre-feet	Implemention costs: City outlay	Customer	Benefits of measure based on avoided cost groundwater	surface water
1991	10%	5	0.500	0.000	0.000	$1,000	$0	$0	$0
1992	20%	5	1.000	1.871	5.742	$1,000	$0	$287	$1,062
1993	30%	5	1.500	1.966	6.033	$1,000	$0	$302	$1,116
1994	40%	5	2.000	2.066	6.340	$1,000	$0	$317	$1,173
1995	45%	5	2.250	2.171	6.662	$1,000	$0	$333	$1,232
1996	50%	5	2.500	2.281	7.000	$1,000	$0	$350	$1,295
1997	55%	5	2.750	2.397	7.356	$1,000	$0	$368	$1,361
1998	60%	5	3.000	2.519	7.730	$1,000	$0	$386	$1,430
1999	65%	5	3.250	2.647	8.122	$1,000	$0	$406	$1,503
2000	70%	5	3.500	2.781	8.535	$1,000	$0	$427	$1,579
2001	75%	5	3.750	2.922	8.968	$1,000	$0	$448	$1,659
2002	80%	5	4.000	3.071	9.424	$1,000	$0	$471	$1,743
2003	80%	5	4.000	3.227	9.903	$1,000	$0	$495	$1,832
2004	80%	5	4.000	3.391	10.406	$1,000	$0	$520	$1,925
2005	80%	5	4.000	3.563	10.934	$1,000	$0	$547	$2,023
2006	80%	5	4.000	3.744	11.490	$1,000	$0	$574	$2,126
2007	80%	5	4.000	3.934	12.074	$1,000	$0	$604	$2,234
2008	80%	5	4.000	4.134	12.687	$1,000	$0	$634	$2,347
2009	80%	5	4.000	4.344	13.331	$1,000	$0	$667	$2,466
2010	80%	5	4.000	4.565	14.009	$1,000	$0	$700	$2,592

Assumptions for estimating benefits and the benefit cost ratio

Avoided cost of groundwater=	$50
Avoided cost of surface water:	$185
Discount rate	3.0%

Benefit cost ratio of the conservation measure:

B/C ratio based on avoided cost of groundwater:

City perspective	0.4
Customer perspective	ERR

B/C ratio based on avoided cost of surface water:

City perspective	1.5
Customer perspective	ERR

promotion, demonstration project; possibly a "bounty" program for reporting violators

City wide savings: million gallons	Acre-feet	Implemention costs: City outlay	Customer	Benefits of measure based on avoided cost groundwater	surface water
0.000	0.000	$3,000	$0	$0	$0
1.871	5.742	$3,000	$0	$287	$1,062
1.966	6.033	$3,000	$0	$302	$1,116
2.066	6.340	$3,000	$0	$317	$1,173
2.171	6.662	$3,000	$0	$333	$1,232
2.281	7.000	$3,000	$0	$350	$1,295
2.397	7.356	$3,000	$0	$368	$1,361
2.519	7.730	$3,000	$0	$386	$1,430
2.647	8.122	$3,000	$0	$406	$1,503
2.781	8.535	$3,000	$0	$427	$1,579
2.922	8.968	$3,000	$0	$448	$1,659
3.071	9.424	$3,000	$0	$471	$1,743
3.227	9.903	$3,000	$0	$495	$1,832
3.391	10.406	$3,000	$0	$520	$1,925
3.563	10.934	$3,000	$0	$547	$2,023
3.744	11.490	$3,000	$0	$574	$2,126
3.934	12.074	$3,000	$0	$604	$2,234
4.134	12.687	$3,000	$0	$634	$2,347
4.344	13.331	$3,000	$0	$667	$2,466
4.565	14.009	$3,000	$0	$700	$2,592

on costs:	Customers ($)	Cost per AF conserved ($)
50	$7,345	$179
50	$11,018	$246
20	$7,345	$452
05	$7,345	$412
40	$7,345	$448
02	$7,345	$249
21	$7,345	$223
89	$7,345	$202
11	$7,345	$184
90	$7,345	$169
29	$7,345	$156
32	$7,345	$148
76	$7,345	$69
19	$7,345	$67
37	$7,345	$65
37	$7,345	$63
22	$7,345	$61
99	$7,345	$59
72	$7,345	$57
48	$7,345	$56

Appendix C

PROGRAM ANALYSIS: MAXIMUM PROGRAM

PROGRAM ANALYSIS: MAXIMUM PROGRAM

Measure: Landscape ordinance for all new construction

Sectors effected: New construction

Assumptions: When combined with metering and other measures, this measure saves about 30 gpcd over entire system

Year	Participation % of new construction	Water savings (gpcd)	Effective savings (gpcd)	City wide savings: million gallons	Acre-feet	Implementation costs: City outlay	Customer	Benefits of measure based on avoided cost: groundwater	surface water
1991	100%	30	30.000	2.582	7.925	$5,000	$0	$396	$1,466
1992	100%	30	30.000	5.296	16.252	$5,000	$0	$813	$3,007
1993	100%	30	30.000	8.147	25.002	$5,000	$0	$1,250	$4,625
1994	100%	30	30.000	11.143	34.197	$5,000	$0	$1,710	$6,326
1995	100%	30	30.000	14.291	43.859	$5,000	$0	$2,193	$8,114
1996	100%	30	30.000	17.600	54.011	$5,000	$0	$2,701	$9,992
1997	100%	30	30.000	21.076	64.680	$5,000	$0	$3,234	$11,966
1998	100%	30	30.000	24.729	75.890	$5,000	$0	$3,795	$14,040
1999	100%	30	30.000	28.567	87.670	$5,000	$0	$4,384	$16,219
2000	100%	30	30.000	32.601	100.048	$5,000	$0	$5,002	$18,509
2001	100%	30	30.000	36.839	113.056	$5,000	$0	$5,653	$20,915
2002	100%	30	30.000	41.293	126.723	$5,000	$0	$6,336	$23,444
2003	100%	30	30.000	45.973	141.086	$5,000	$0	$7,054	$26,101
2004	100%	30	30.000	50.891	156.177	$5,000	$0	$7,809	$28,893
2005	100%	30	30.000	56.058	172.036	$5,000	$0	$8,602	$31,827
2006	100%	30	30.000	61.488	188.700	$5,000	$0	$9,435	$34,910
2007	100%	30	30.000	67.194	206.211	$5,000	$0	$10,311	$38,149
2008	100%	30	30.000	73.190	224.611	$5,000	$0	$11,231	$41,553
2009	100%	30	30.000	79.490	243.946	$5,000	$0	$12,197	$45,130
2010	100%	30	30.000	86.110	264.263	$5,000	$0	$13,213	$48,889

Assumptions for estimating benefits and the benefit cost ratio

Avoided cost of groundwater=	$50
Avoided cost of surface water:	$185
Discount rate	3.0%

Benefit cost ratio of the conservation measure:

B/C ratio based on avoided cost of groundwater:

City perspective	1.0
Customer perspective	ERR

B/C ratio based on avoided cost of surface water:

City perspective	3.9
Customer perspective	ERR

Measure: Seasonal pricing of water and steep inverted block rate structure

Sectors effected: All

Assumptions:

Year	Participation % of metered connections	Water savings (gpcd)	Effective savings (gpcd)	City wide savings: million gallons	Acre-feet	Implemention costs: City outlay	Customer	Benefits of measure based on avoided cost groundwater	surface water
1991	0%	0	0.000	0.000	0.000	$0	$0	$0	$0
1992	0%	0	0.000	0.000	0.000	$0	$0	$0	$0
1993	0%	0	0.000	0.000	0.000	$0	$0	$0	$0
1994	0%	0	0.000	0.000	0.000	$0	$0	$0	$0
1995	0%	0	0.000	0.000	0.000	$0	$0	$0	$0
1996	60%	40	24.000	14.080	43.209	$15,000	$0	$2,160	$7,994
1997	70%	40	28.000	19.671	60.368	$2,000	$0	$3,018	$11,168
1998	80%	40	32.000	26.378	80.950	$2,000	$0	$4,047	$14,976
1999	90%	40	36.000	34.281	105.204	$2,000	$0	$5,260	$19,463
2000	100%	40	40.000	43.468	133.398	$2,000	$0	$6,670	$24,679
2001	100%	40	40.000	49.119	150.741	$2,000	$0	$7,537	$27,887
2002	100%	40	40.000	55.057	168.965	$2,000	$0	$8,448	$31,258
2003	100%	40	40.000	61.297	188.114	$2,000	$0	$9,406	$34,801
2004	100%	40	40.000	67.854	208.237	$2,000	$0	$10,412	$38,524
2005	100%	40	40.000	74.744	229.381	$2,000	$0	$11,469	$42,436
2006	100%	40	40.000	81.984	251.600	$2,000	$0	$12,580	$46,546
2007	100%	40	40.000	89.592	274.948	$2,000	$0	$13,747	$50,865
2008	100%	40	40.000	97.586	299.481	$2,000	$0	$14,974	$55,404
2009	100%	40	40.000	105.987	325.261	$2,000	$0	$16,263	$60,173
2010	100%	40	40.000	114.814	352.350	$2,000	$0	$17,618	$65,185

Assumptions for estimating benefits and the benefit cost ratio

Avoided cost of groundwater=	$50
Avoided cost of surface water:	$185
Discount rate	3.0%

Benefit cost ratio of the conservation measure:

B/C ratio based on avoided cost of groundwater:

City perspective	2.9
Customer perspective	ERR

B/C ratio based on avoided cost of surface water:

City perspective	10.9
Customer perspective	ERR

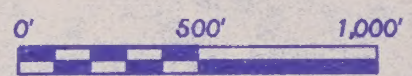
Subtotal of water savings due to maximum program

Year	Acre-feet conserved (acre-feet)	New demand (acre-feet)	Safe annual yield (acre-feet)	Baseline usage (gpcd)	"Maximum" usage (gpcd)	Implementation costs: City ($)	Customers ($)	Cost per AF conserved ($)
1991	98	1,495	4,000	291	274	$13,750	$7,345	$216
1992	143	1,537	4,000	293	268	$25,250	$11,018	$253
1993	167	1,608	4,000	294	266	$61,620	$7,345	$414
1994	191	1,683	4,000	296	266	$62,305	$7,345	$365
1995	217	1,764	4,000	297	265	$75,140	$7,345	$380
1996	363	1,732	4,000	299	247	$78,802	$7,345	$237
1997	425	1,792	4,000	301	244	$66,621	$7,345	$174
1998	492	1,856	4,000	304	240	$67,489	$7,345	$152
1999	566	1,923	4,000	306	237	$68,411	$7,345	$134
2000	645	1,995	4,000	309	234	$69,390	$7,345	$119
2001	716	2,087	4,000	313	233	$70,429	$7,345	$109
2002	782	2,196	4,000	316	233	$71,532	$7,345	$101
2003	852	2,316	4,000	320	234	$35,976	$7,345	$51
2004	926	2,448	4,000	324	235	$37,219	$7,345	$48
2005	1,003	2,594	4,000	329	237	$38,537	$7,345	$46
2006	1,085	2,755	4,000	334	240	$39,937	$7,345	$44
2007	1,171	2,933	4,000	340	243	$41,422	$7,345	$42
2008	1,261	3,132	4,000	346	247	$42,999	$7,345	$40
2009	1,357	3,352	4,000	353	251	$44,672	$7,345	$38
2010	1,458	3,599	4,000	361	257	$46,448	$7,345	$37

LEGEND

- VALVE
- VALVE VAULT
- 10" REHABILITATION PROGRAM PIPE DIAMETER
- 10" FUTURE PIPE DIAMETER
- FIRE HYDRANT
- BLOWOFF
- WELL
- ELEVATED STORAGE TANKS

CITY OF WINTERS

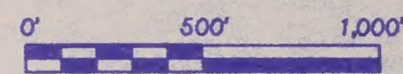


APRIL 1992

LEGEND

- VALVE
- VALVE VAULT
- 10" EXISTING PIPE DIAMETER
- FIRE HYDRANT
- BLOWOFF
- WELL
- ELEVATED STORAGE TANK

CITY OF WINTERS



APRIL 1992